November 2009

The Region of the Head

REGIONAL ANATOMY.

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IN ITS RELATION TO

MEDICINE AND SURGERY.

THE REGION OF THE HEAD.

The surface-form of the head is always pronounced, because the prominences and depressions, or *landmarks* (Plate 1), of the skull are slightly masked by the overlying soft structures.

The thickness of the skull-cap varies greatly, and can only be conjectured from external appearances. The average thickness is five millimetres, or one-fifth of an inch; the thickest parts are in the basilar portions, which are originally developed in cartilage, whereas the bones composing the vault are formed in membrane. In no other part of the skeleton is the combination of strength and lightness so beautifully adapted to its purposes as in the cranium.

The contour of the head itself tends to avert the effect of external violence received at any point, and the natural eminences and processes occur where protection to the brain is most needed, while in those parts where it is less needed the bones are thin and light, so as to serve as a covering with but little extra weight.

The hollows or sinuses of the cranial bones are rudimentary at birth, and remain of small size up to about the ninth year, after which they gradually increase until puberty, when they undergo great enlargement.

The bones of the cranium are the frontal, two parietal, occipital, two temporal, sphenoid, and ethmoid. They are immovably connected in the adult at their edges by the *sutures,* which vary in character according to their position and adaptation. The frontal bone is originally developed in two portions, which become joined by the *frontal suture* shortly after birth. This suture usually closes rapidly, so that it is obliterated between the second and sixth years, but occasionally it may persist to the end of a long life. Continued backward approximately in the middle line from the root of the nose and along the course of the frontal suture to the occipital bone is the *interparietal* or *sagittal suture,* by which the two parietal bones are dovetailed together. The parietal bones are connected with the frontal bone by the *coronal suture,* and with the occipital by the *lambdoid suture.* The coronal suture is more deeply indented laterally than above, and the lambdoid is remarkable for the tortuous course of its deep dentations. The junction of the coronal and sagittal sutures, the *bregma,* may be ascertained on the living head by drawing upward from the external auditory openings two lines, which will meet over this point on the top of the head when it is held in the erect position.

The point of junction of the lambdoid and sagittal sutures, the *lambda,* is in the middle line, one-third of the distance from the external occipital protuberance to the bregma. The lambdoid suture may be represented by a line drawn from the lambda to the apex of the mastoid process on each side. The coronal suture corresponds to a line drawn from the bregma to the middle of the zygomatic arch. The point where the anterior inferior angle of the parietal bone is joined to the great wing of the sphenoid bone is the *pterion,* and is three centimetres, or about an inch and a quarter, behind the external angular process of the orbit. At the sides, the arches of the skull are maintained by the thin scaly margins of the temporal bones overlapping the bevelled lower edges of the parietal bones, forming the *squamous sutures.* The top of each squamous suture is five centimetres, or about two inches, above the zygoma in the adult head.

The dentate sutures are formed by serrations mainly from the *outer* table of the bones of the vertex interlocking. They gradually disappear after the fortieth year, the cranial bones becoming fused together in old age (synosteosis), when they, like the rest of the skeleton, become more porous and brittle and are in consequence more readily fractured.

The closure of the cranial sutures usually begins on the *inside* of the vault, but there is great variability as to the time and order in which it takes place.

The age of an individual cannot be determined from the state of the cranial sutures. They sometimes disappear at an early age. The author has several specimens where not a sign of the coronal, sagittal, or lambdoid sutures remains at the ages of thirty-three and thirty-seven years.

At birth all the tabular bones are soft and yielding and capable of overlapping one another, thereby facilitating the delivery of the head of the child. In the subsequent growth of the bones the compact layers are produced, forming the *outer* and *inner tables*, with an intervening cancellated structure, the *diploë*. In old persons the diploë is often absorbed, so that the skull in some places becomes very thin, and it should be borne in mind that the plane of the inner table is not always equidistant from that of the outer, a matter of no little moment in applying the trephine.

The limiting membranes of the vertex bones are united at the lines of the sutures, and until ossification is completed there are interspaces at the angles of the parietal bones, known as the *fontanelles*. These usually close in shortly after birth, with the exception of the anterior fontanelle, which occupies the bregma and does not disappear until the end of the second year. Until this is completely closed by ossific matter, there is a depression in this locality, through which there is a regular pulsation perceptible, due to the action of the arteries of the brain. Persistence of the anterior fontanelle is generally indicative of hydrocephalus.

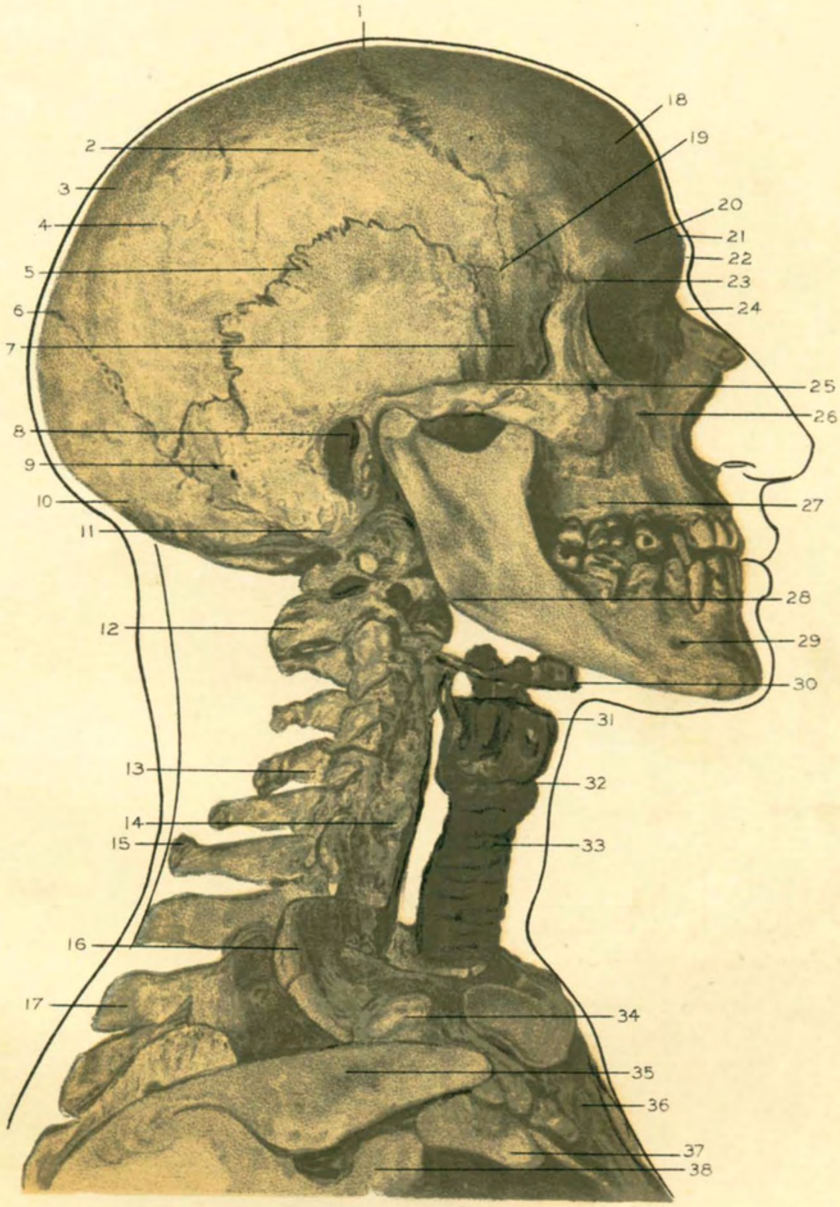
Occasionally congenital fissures occur before the normal approximation of the skull bones is completed. They most commonly occupy the occipital region, and when they persist in the position of the lambdoid

PLATE 1.

The landmarks of the skeleton of the regions of the head, face, and neck, on the right side, with their relations to the surface coverings.

1. The point of junction of the coronal and sagittal sutures (*the bregma*).
2. The temporal ridge, for the temporal fascia.
3. The parietal foramen (*the obelion*).
4. The parietal eminence.
5. The squamous suture.
6. The point of junction of the lambdoid and sagittal sutures (*the lambda*).
7. The great wing of the sphenoid bone (*the pterion*).
8. The external auditory meatus.
9. The mastoid foramen (*the asterion*).
10. The external occipital protuberance (*the inion*).
11. The mastoid process of the temporal bone.
12. The spine of the second cervical vertebra.
13. The spine of the fifth cervical vertebra.
14. The transverse process of the sixth cervical vertebra, with first foramen for the vertebral artery.
15. The spine of the seventh cervical vertebra (*the vertebra prominens*).
16. The first rib.
17. The spine of the second dorsal vertebra.
18. The frontal eminence.
19. The anterior inferior angle of the parietal bone.
20. The supra-orbital foramen.
21. The superciliary ridge (*the ophryon*).
22. The glabella.
23. The external angular process.
24. The junction of the frontal and nasal bones (*the nasion*).
25. The zygomatic arch.
26. The infra-orbital foramen.
27. The second upper molar tooth.
28. The angle of the lower jaw (*the gonion*).
29. The mental foramen.
30. The top of the hyoid bone.
31. The top of the thyroid cartilage.
32. The cricoid cartilage.
33. The second ring of the trachea.
34. The acromial end of the clavicle.
35. The acromion process of the scapula.
36. The top of the sternum (*the manubrium*).
37. The coracoid process of the scapula.
38. The glenoid fossa of the scapula.

N. B.—This plate was taken from the skeleton of a well-developed European male, aged about thirty-seven years.



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sutures they may be mistaken for fractures. In this locality also are frequently found isolated triangular bony pieces (*Wormian bones*), originating from accessory centres of ossification (Plate 3, Fig. 3, Nos. 4 and 13). Supernumerary bones are also often found in hydrocephalic skulls.

The *superciliary ridges* are the prominences which support the eyebrows. They indicate in a measure the size of the *frontal sinuses* within the bone, which are first formed by absorption of the spongy substance (diploë) at the inner angular processes of the orbits, and gradually spread upward and outward.

The dimensions of the frontal sinuses (Plate 12, No. 25) cannot always be foretold by the external conformation of the ridges; and they often appear to be formed by a retrocession of the inner table, especially in elderly people. They reach a greater degree of development in the male than in the female. They are usually unsymmetrical, the larger being on the side from which the nasal septum is bent.

The frontal sinuses connect with the anterior ethmoidal cells and the middle meatus of the nose by a curved canal called the *infundibulum* (page 113). The intervening point between the two superciliary ridges is called the *ophryon.* Above the ridges are the *frontal eminences* (Plate 2, No. 4, and Plate 28, No. 35), indicating the centres of primary ossification of the original two halves of the frontal bone of infancy, and corresponding in a measure to the development of the anterior lobes of the cerebral hemispheres. The *glabella* is the smooth area between the superciliary ridges above the nose. Just below it is the point of junction of the nasal bones with the frontal spine,—the *nasion.*

The *external angular processes* of the orbits are the outer limits of the superciliary ridges. The glabella and the angular processes are subcutaneous, the ridges being covered by the superciliary muscles and integument (Plate 1). The *supraorbital foramen* or *notch* is on the border of the orbital arch, just below the superciliary ridge, two and a half centimetres, or about an inch, from the external angular process.

The *temporal ridge,* for the attachment of the temporal fascia, starts from the external angular process and arches backward, usually midway between the squamous and sagittal sutures. The temporal muscle is attached one centimetre, or about half an inch, below the attachment of the temporal fascia, and sometimes a second distinct ridge is noticeable on the cranium. The point of intersection of the upper temporal ridge with the coronal suture is the *stephanion.*

The *parietal foramina* are approximately midway between the bregma and the external occipital protuberance. They are very near the middle line, and the area of the brain-case in their locality is often flattened. This area is called the *obelion.* The *parietal eminences* are the points where ossification first began in the parietal bones. They are very noticeable, and correspond to the development of the lateral lobes of the cerebrum.

The *external occipital protuberance,* the *inion,* is on a line drawn horizontally backward from the sockets of the incisor teeth of the upper jaw. This process is the thickest part of the cranium, but is not always so prominent that it can be detected through the scalp. From it on each side the *superior curved line* arches outward toward the mastoid process. The *mastoid processes* are hardly noticeable during childhood. There is a continuous formation of new bone from the periosteum on the surface between infancy and puberty, and during this period the process consists of cancellous tissue which can be readily penetrated by the knife in mastoid disease. At puberty this cancellous tissue becomes hollowed by absorption into air-cells, and a larger cavity, the mastoid antrum, all of which communicate with one another and are connected with the tympanum. The antrum is separated from the cranial cavity by only a thin roof of bone (Plate 3, Fig. 5, No. 1). The cells vary in size in different bodies, and on the two sides of the same head. The proximity of the lateral sinus renders it liable to become involved by extension of inflammation in suppurative disease of the mastoid cells, especially in the adult.

The *mastoid foramen* is situated near the junction of the mastoid portion of the temporal bone and the occipital. It is the largest of several foramina in this locality, and transmits a vein to the lateral sinus, and sometimes a small artery to the dura mater.

The petrous portions of the temporal bones are hard and dense upon their surfaces, but, as they are hollowed within for the lodgement of the structures composing the middle and the internal ear, they are liable to fracture. The skull is not inherently strong at its base, and although undoubtedly fractures do occur in this region by transmitted force from blows upon the vertex, yet fracture by *contre-coup* is not now admitted to be so probable as it was formerly thought to be.

The discharge of cerebro-spinal fluid from the ear, which is one of the diagnostic signs of fracture at the base of the skull, indicates that the internal auditory meatus must have been fractured and that a communication has been established between the tympanum and the internal ear.

Sometimes a serous discharge from the ear follows injury to the head, where fracture has not taken place: this is due to escape of fluid from the mastoid cells through a rupture in the tympanic membrane.

Injuries involving the base of the skull must of necessity be serious, as in this region the cavity of the skull is in relation with the nasal cavity, the orbit, the frontal sinuses, the sphenoidal sinus, the tympanic cavity, the upper part of the pharynx, and the spinal cord. Besides these there are the foramina which give exit to the cranial nerves (Plate 3, Figs. 1 and 5; Plate 4, Fig. 2; Plate 5, Fig. 2; Plate 11, Figs. 1 and 3; Plate 12; and Plate 13).

The skin covering the head, which constitutes the **scalp,** is peculiarly constructed for the growth of the hair and for protection to the vault of the cranium. It is thicker than in any other part of the body, and is closely connected by means of the subcutaneous tissue with the aponeuroses of the occipito-frontales muscles, so that it moves freely with their contraction. This mobility is very noticeable in infancy. The readiness with which the whole thickness of the scalp gives way in contused wounds is due to the intimate connection between the skin and the subjacent textures.

The subcutaneous tissue here consists of a dense fibrous structure enclosing fat lobules (Plates 9 and 12), and resembles that of the palm of the hand. This continues with the superficial fascia over the muscles at the back of the neck, and at the sides passes over the temporal fascia.

The vessels, nerves, hair-bulbs, and sebaceous glands are contained within the meshes of this subcutaneous tissue.

The *scalp hairs* mostly diverge from the obelion. They vary in character according to their color, length, and diameter, and the manner in which the hair-follicles are set in the skin, being straight, wavy, curly, or woolly, according to the straight or the curved axis of each follicle. Fair hairs are finer and more delicate than dark hairs, and are usually more closely set in the scalp.

The arteries of the scalp are the terminal branches of the temporal, supra-orbital, frontal, posterior auricular, and occipital. They pass toward the vertex of the head, running in a tortuous course from their origins. The *temporal artery* is the continuation of the external carotid artery after it has tunnelled through the upper part of the parotid gland (Plate 18, No. 37). It is six millimetres, or a quarter of an inch, in front of the ear, and is accompanied by the temporal vein and the auriculo-temporal nerve. It divides into the anterior and middle temporal branches, which run immediately under the skin (Plate 17, No. 1), and may serve to indicate the pulse to the physician. The *supra-orbital artery* ascends with the supra-orbital nerve (Plate 18, No. 1) from the supra-orbital notch, or foramen, which is situated two and a half centimetres, or about an inch, from the outer orbital angle, toward the nose on the border of the orbital arch. The *frontal artery* and supratrochlear nerve (Plate 19, No. 1) pass upward between the supra-orbital notch and the root of the nose.

The supra-orbital and frontal arteries come from the ophthalmic artery within the orbit. The *posterior auricular artery* and the *occipital* (Plate 20, Nos. 45 and 50) are branches of the external carotid artery. The former passes with the posterior auricular nerve in a groove behind the mastoid process of the temporal bone, and the occipital artery, accompanied by the great occipital nerve, reaches the scalp at a point midway between the external occipital protuberance and the mastoid process. The anterior branch of the temporal artery often becomes very tortuous in the aged, and sometimes undergoes calcareous degeneration.

Owing to the toughness of the scalp in which the arteries ramify, they cannot be drawn out, and do not retract when divided, as they do elsewhere, and hence incised wounds in this region are frequently attended with troublesome hemorrhage.

The veins of the scalp are quite large, and in a measure accompany the arteries, receiving similar names in their different localities, but their course is more direct and they freely anastomose. There are two *frontal veins*, which generally run parallel at the middle of the forehead, sometimes being very prominent in life, and are united at the root of the nose by a transverse trunk called the nasal arch. Thence they branch into the angular veins of the face, being joined by the supraorbital veins. At this point they receive branches from the superior ophthalmic veins and establish direct communication with the cavernous sinuses at the base of the brain. Sometimes there is only *one* temporal vein.

The *temporal veins* commence by anastomosing plexuses on the top of the head which form into anterior and posterior branches, and unite into main trunks in close relation to the temporal arteries at the zygoma, where they receive the blood from the middle temporal veins coming from the substance of the temporal muscles. The *posterior auricular veins* descend behind the ear, receiving the stylo-mastoid veins, and empty into the temporo-maxillary veins. The *occipital veins* follow the course of the occipital arteries, passing beneath the deep muscles at the back of the neck and terminating usually in the internal jugular veins. At the mastoid portion of the temporal bone the *mastoid vein* enters the occipital or the posterior auricular, thus communicating with the lateral sinus. This is the largest and most constant of the so-called *emissary veins*, which connect the extra- and the intra-venous circulation. Besides the intercommunication by the ophthalmic and angular veins and the mastoid and occipital veins, there are many others which are less constant, but of equal importance when they do occur. The parietal foramina are at the vertex in the vicinity of the median line, where the interlocking of the serrated edges of the parietal bones forms the sagittal suture, and transmit veins from the scalp to the longitudinal sinus. There is generally a vein connecting the lateral sinus with the deep veins at the back of the neck through the posterior condyloid foramen, on one side or the other; and there are many apertures at the base of the skull through which veins pass connecting the cavernous sinuses with the venous plexuses of the pharynx and the internal jugular veins. A similar connection exists more often than is supposed between the veins of the nasal fossæ and the front part of the longitudinal sinus through the *foramen cæcum*, which in such cases is not closed. There are also minute veins which connect the diploic veins (Plate 3, Fig. 4) within the tabular bones of the skull with the veins of the scalp. The emissary veins are well worthy the attention of the physician or surgeon, for through their various channels inflammation often spreads from the surface to the interior of the head, or the reverse; as is witnessed where erysipelas of the scalp induces meningitis, or in external abscess following injury to a sinus by a fracture or the application of the trephine.

The lymphatic vessels of the scalp are in relation to the principal veins. The *frontal lymphatics* descend from the forehead and eyebrows, some going to the lymphatics of the face and ending in the submaxillary lymphatic glands, while the greater number converge toward the front of the ear, where they enter the lymphatic glands of the parotid region (Plate 16, No. 15). The *parietal lymphatics* pass to the mastoid glands, are four or five in number, and lie about the insertion of the sterno-mastoid muscle. The *occipital lymphatics* go partly to the sub-occipital glands in front of the occipital attachment of the trapezius muscle, and partly to the deep cervical glands beneath the sterno-mastoid muscle at the middle of the neck. The frontal, parietal, and occipital lymphatic vessels all communicate with one another.

The nerves of the scalp have been considered in their relations with the arteries. It will be noticed that they also pass toward the vertex of the head.

In front are the *supra-orbital* and *supra-trochlear* branches of the ophthalmic division of the fifth cranial nerve,—the *trifacial* (Plate 3, Fig. 2). They give sensation to the integument over the top of the head and forehead (Plate 53, Fig. 1, Nos. 1 and 13).

The supra-orbital nerve is often the seat of frontal neuralgia, which probably depends much upon whether the nerve issues from a distinct bony foramen or only from a notch. In the temporal region are the filaments from the *orbital branch* of the superior maxillary division, and the *auriculo-temporal nerve* from the inferior maxillary division, of the fifth nerve (Plate 19, No. 20). All of these supply sensation. The motor nerves are derived from the temporal branches of the facial nerve, which pass upward from among the lobules of the parotid gland to the anterior portion of the occipito-frontalis, corrugator, supra-auricular, and anterior auricular muscles. Behind are the *posterior auricular branch* of the facial nerve, giving motion to the posterior portion of the occipito-frontalis and posterior auricular muscles, and the *small* and *great occipital nerves* (Plate 22, Fig. 1, Nos. 3 and 8), the former a branch of the anterior division and the latter a branch of the posterior division of the second cervical nerve. These last are the sensory nerves to the skin over the back of the head. The *auricular branch* of the pneumogastric nerve (Arnold's) emerges from the auricular fissure just behind the concha of the ear, which it supplies. The nerves of the scalp communicate frequently with one another.

The cutaneous muscle of the scalp, the occipito-frontalis, consists of two fleshy portions, the frontal and the occipital, united by a broad aponeurosis, which is continuous with the aponeurosis of the opposite muscle across the vertex and forms the *galea capitis* (Plate 15, No. 1). In bald persons the frontal muscles often plainly show in outline on the sides of the forehead.

The *frontal portion* is a thin layer of pale fleshy fibres extending upward five centimetres, or about two inches, on the side of the forehead, where it joins the aponeurosis. In the middle line, at the nasion, the fibres blend with those of the fellow muscle, sending a slip downward to intersect with the pyramidal nasal muscle. The middle and outer fibres commingle with those of the orbicular and corrugator muscles at the eyebrows. Some of the innermost fibres are attached to the nasal bones, some of the outer to the external angular process of the orbit (Plate 15, No. 3). The *occipital portion* is of a darker color than the frontal. It takes origin by a tendinous insertion on the outer part of

PLATE 2.

Figure 1.

Skull showing topographical survey of the relations of the sutures and eminences to the principal fissures of the brain, and the approximate lower level line of the cerebrum.

1. *The bregma*, the junction of the coronal and sagittal sutures.
2. *The superior frontal sulcus.*
3. *The posterior frontal or vertical sulcus.*
4. *The frontal eminence.*
5. *The superior stephanion*, or intersection of the ridge for the temporal fascia with the coronal suture, in its relation to the inferior frontal sulcus.
6. The line indicating the anterior limit of the corpus striatum.
7. *The glabella* (or *ophryon*).
8. *The pterion*, the junction of the great wing of the sphenoid bone with the frontal, parietal, and temporal bones, indicating the position of the ascending branch of the fissure of Sylvius in its relation to the coronal suture.
9. *The nasion*, the junction of the nasal and frontal bones.
10. The external angular process of the orbit.
11. *The fissure of Rolando.*
12. *The inter-parietal sulcus.*
13. *The parietal eminence.*
14. *The squamo-parietal suture* in relation to the horizontal branch of the fissure of Sylvius.
15. The line indicating the posterior limit of the optic thalamus.
16. *The upper temporo-sphenoidal sulcus.*
17. *The external parieto-occipital fissure.*
18. *The lambda*, the junction of the lambdoid and sagittal sutures.
19. *The lower temporo-sphenoidal sulcus.*
20. *The inion*, the external occipital protuberance.

Figure 2.

The left side of skull with the parietal bone removed, showing the subjacent convolutions of the left cerebral hemisphere (stripped of their membranes), with topographical survey of the motor area of the opercular region thus exposed.

1. The centre for the movements of the face (the expressions).
2. The centre for the movements of the lips, tongue, throat, and larynx.
3. The speech centre.
4. The pre-central, or posterior, frontal sulcus.
5. The ascending frontal convolution.
6. The ascending branch of the fissure of Sylvius.
7. The centre for the movements of the fingers.
8. The centre for the movements of the thumb.
9. The centre for the movements of the wrist.
10. The centre for the movements of the shoulder and elbow.
11. The centre for the movements of the hip, knee, and leg.
12. The centre for the movements of the foot and toes.
13. The fissure of Rolando.
14. The ascending parietal convolution.
15. The horizontal branch of the fissure of Sylvius.
16. The external parieto-occipital fissure.
17. The cerebellum.

Fig 1

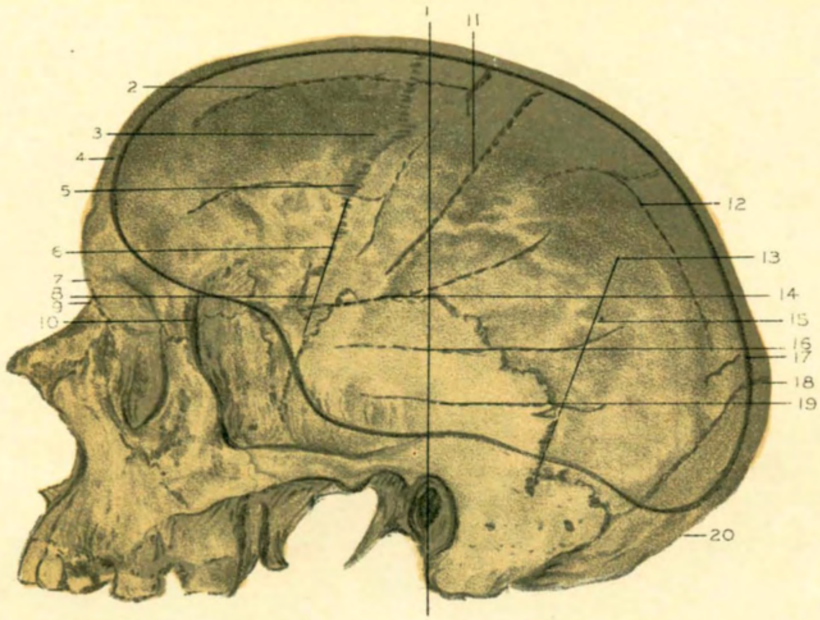
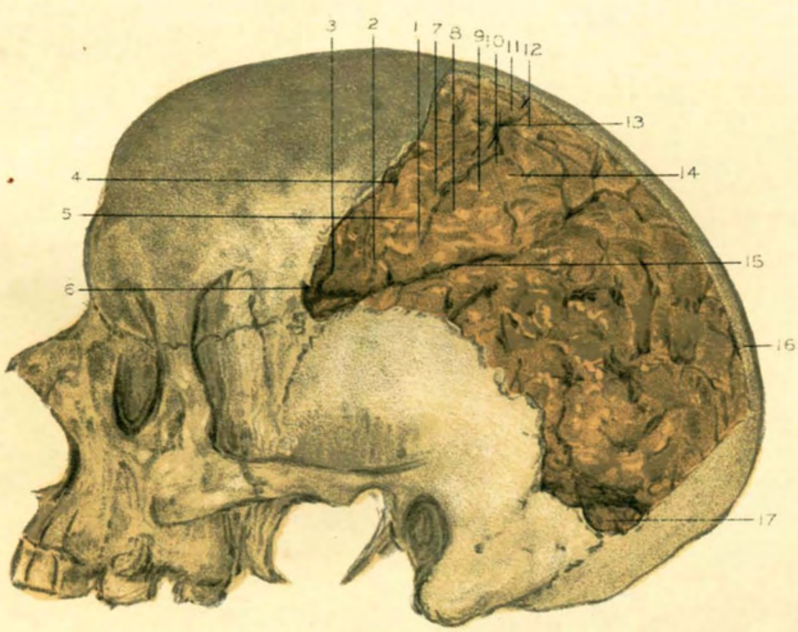


Fig 2



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the upper curved line of the occipital bone and the mastoid portion of the temporal bone, and, immediately becoming muscular, its parallel fibres extend upward three centimetres, or about an inch, and then join the aponeurosis. The *aponeurosis of the scalp* is continuous across the top of the head, and is more characteristic behind, where there is a median area chiefly composed of longitudinal fibres which are attached to the external occipital protuberance and adjoining portions of the upper curved line. It is thinner in front, and at the sides, in the temporal region, it is not so closely associated with the scalp, being continued over the subjacent temporal fascia as far as the zygoma. Between the aponeurosis (*epicranium*) and the delicate membrane overlying the skull bones (*pericranium*) there is a layer of loose connective tissue, upon which the mobility of the scalp depends. This mobility is readily seen in the raising of the brows by contraction of the frontal muscles, in many of the ordinary facial expressions, and the laxity of the connective tissue is demonstrated in extensive scalp wounds, where a large flap may be peeled off from the skull. Incised wounds gape most when they occur across the direction of the fibres of the muscle. The attachments of the occipito-frontales muscles, above described, constitute a limited area of surgical significance in case of wounds and inflammatory affections attended with suppuration in this region. This area is roughly indicated by a line drawn round the head from the superciliary ridges above the zygoma to the occipital protuberance. The pericranium is very thin in the adult, and exercises only a protective influence over the skull bones, playing no part in their nourishment. It is unlike the periosteum elsewhere, being destitute of its bone-producing properties, the bones of the cranium receiving their nutrition from the vessels of the dura mater.

The pericranium may be regarded as the remains of the outer layer of the developing membrane which surrounded the bones in early life. It is very slightly attached, except at the sutures, where, in the young, it blends with the membrane between the soft and growing bones. In the latter instance sometimes extravasations occur, due generally to pressure on the head at birth, which are limited to one bone, commonly the parietal. In the temporal region the pericranium is more adherent to the bone than anywhere else.

The temporal region corresponds with the temporal muscle, which occupies the temporal fossa. The skin here is somewhat different from the scalp proper, having a variable quantity of fat in its subcutaneous tissue, besides the rudimentary auricular muscles.

The *temporal fascia* is a bluish-white shining aponeurosis, underlying the above, of a very unyielding nature, which firmly binds down the temporal muscle, and sends radiating tendinous slips among the outer bundles of fibres of the muscle which greatly augment its power. Above it is attached to the upper temporal ridge on the frontal and parietal bones, and below it is separated into two leaflets which are inserted into the outer and inner borders of the zygomatic arch. There is usually a pad of fat between the muscle and its aponeurosis at the zygoma, the wasting of which in emaciation and in old age occasions conspicuous hollows at the temples.

When the *temporal muscle* is stripped of its fascia, it presents a fan-shaped appearance (Plate 21, No. 2), with its fibres converging into a strong tendon, which is inserted into the coronoid process of the lower jaw at its apex and anterior border. The temporal muscle arises from the side of the skull one centimetre, or a half-inch, below the attachment of the fascia. Its deeper surface is in relation to the deep temporal arteries and nerves and to the internal maxillary vessels. Its motor nerves are derived from the inferior maxillary nerve. The function of the temporal muscle is to raise the lower jaw forcibly against the upper. With the masseter (page 122) and pterygoid muscles it is concerned in the mastication of food.

The *inequality of the thickness of the skull-cap* has already been mentioned. It depends upon the amount of the diploë between the outer and inner tables of compact bone. This structure varies considerably, and its amount cannot be determined before a section of the bone is made. The diploë contains a number of large veins, which occupy channels in its structure and freely anastomose (Plate 3, Fig. 4) and at points have extra- and intra-communications with the veins of the scalp and the sinuses of the dura mater. When the diploë is reached by the teeth of a trephine saw, the blood from the *diploic veins* wells up in a peculiar and distinctive manner.

The inner table of compact bone is thinner and more brittle than the outer, and is in consequence called the *vitreous table.* Thus its fracture is accounted for in those cases where it has been broken without the outer table being implicated; and in nearly all cases of complete fracture of the skull bones it is the internal table which is most broken. The egg-shaped form of the skull has undoubtedly much to do with the diversion of the effects of violence from the brain, and explains the possibility of the occurrence of fracture at the base of the skull from *contre-coup.*

When the skull-cap is removed its inner surface is found to be grooved for the branches of the meningeal arteries at the sides, and along the median line about the attachment of the walls of the superior longitudinal sinus of the dura mater are depressions for the reception of the so-called *Pacchionian bodies.*

× **The dura mater** is the white, dense, fibrous membrane which lines the interior of the skull, serving the double purpose of being the true (nutritive) periosteum of the cranial bones and of affording a tough protective envelope and support to the brain. It is closely adherent over the whole of the base of the skull, where it is prolonged through the foramina, becoming continuous with the pericranium and blending with the fibrous sheaths of the nerves and vessels which pass out of and into the cranium. Over the vault its attachments are chiefly in the position of the sutures, where its outer fibrous layer separates to form the venous sinuses. Elsewhere it is comparatively loose, so that extravasations from rupture of the meningeal vessels or purulent accumulations may collect between the dura mater and the bone and cause compression of the brain. When compression occurs immediately on the receipt of an injury to the head, it is generally due to a depressed fragment of bone; but if it follows after an interval it is probably caused by an extravasation of this sort. It is worthy of note in this connection that rupture of a vessel of the dura is usually followed by symptoms of compression more pronounced than when one of the *cerebral* vessels is involved, owing to the softer and more yielding nature of the brain-substance. On the other hand, when a cerebral vessel is ruptured there is little impediment to the escape of the blood, and often clots of great size are found in the locality of one of the cerebral vessels. Even in the lines of the sutures the dura mater can be severed from its bony attachment by taking pains in the removal of the skull-cap (Plate 4, Fig. 2), and there is little danger of wounding any of the sinuses with the trephine if the button of bone, when it has been cut through by that instrument, is seized with the forceps and extracted by a gentle rotatory motion. During the growth of the skull bones in childhood the dura mater is very adherent, and does not allow extravasations to collect between it and the inner wall of the cranium.

The *Pacchionian bodies,* depressions for which are often noticed on the inner table of the skull-cap, are clusters of whitish granulations of variable size (Plate 5, Fig. 1). They first appear about the seventh year, and increase in number as age advances. The localities in which they are liable to be found are the neighborhood of the great longitudinal sinus, on the outer surface of the dura, and sometimes within the walls of the sinus itself. They are also, but rarely, met with in the fissure of Sylvius and on the margins of the hemispheres. They have been demonstrated to be hypertrophied villi of the arachnoid membrane, which perforate the dura mater by pressing outward, and cause the formation of the pits in the bone by absorption.

The dura mater sends vertical processes between the hemispheres of the cerebrum and those of the cerebellum, and a transverse arching partition between the posterior lobes of the cerebrum and the cerebellum (Plate 4, Fig. 1). The latter is called the *tentorium,* and serves to prevent the posterior lobes of the cerebrum from pressing upon the cerebellum. It is attached to the transverse ridges upon the inner surface of the occipital bone, and extends laterally to the superior borders of the petrous portion of the temporal bones, and forward to the clinoid processes of the sphenoid bone. The vertical processes are known respectively as the *falx cerebri* and the *falx cerebelli.* The falx cerebri is received into the longitudinal fissure between the two cerebral hemispheres. It is attached in front to the crista galli of the ethmoid bone by a sharp point, and gradually becomes broader as it arches backward, assuming the characteristic shape of the blade of a sickle. At its back part it is connected with the upper surface of the tentorium. The falx cerebelli is projected into the notch between the hemispheres of the cerebellum and extends to the sides of the foramen magnum.

The *arteries of the dura mater* are very numerous, but the one of chief importance is the *great* or *middle meningeal artery* (Plate 9, Fig. 2). This vessel is a branch of the internal maxillary artery, and enters the skull at the foramen spinosum in the margin of the great wing of the sphenoid bone where it joins the anterior inferior angle of the parietal bone, at the middle fossa of the skull. It passes upward over the side of the dura mater in close connection with its two veins, and divides into anterior and posterior branches, which are received by grooves or channels in the inner table of the parietal bone. Very often these channels become in places distinct bony *tunnels*, so that removal of a section of the bone so constructed necessitates the rupture of the embedded artery. At the lower anterior angle of the parietal bone fracture is very liable to occur, because the bone is peculiarly thin and weak, and, although the dura mater is adherent here, in such an injury the vessel can hardly escape laceration. In almost every case of fracture of the *vault* of the skull, attended with extravasation of blood, it is one or other of the branches of the middle meningeal artery which gives way, and this may even occur without fracture, owing to the loose attachment of the dura mater within the vault being separated by the vibration produced by a blow.

The other arteries which supply the dura mater and the various regions of the skull are, in the temporal region, the *lesser meningeal*, which enters at the foramen ovale coming from the internal maxillary (Plate 22, Fig. 2), and a small twig from the *ascending pharyngeal artery*, which comes through the middle lacerated foramen at the base of the skull. Anteriorly there are meningeal arteries from the ethmoid and internal carotid arteries, and posteriorly branches from the occipital, ascending pharyngeal, and vertebral arteries. The first two enter by the jugular foramen, and the latter by the foramen magnum.

All the *veins of the dura mater*, with the exception of the two which accompany the middle meningeal artery on either side, terminate in the great sinuses. They freely anastomose with the diploic veins. The dura mater not only affords support to the divisions of the brain-mass, but in certain places separates into two layers, so as to form canals, or *sinuses*, by which the venous blood from the brain and its membranes is conveyed without interference to the internal jugular veins.

There are as many as fifteen of these sinuses, but the most important (from a surgical point of view) are the superior longitudinal and the lateral (Plate 4, Figs. 1 and 2). The *lateral sinuses* are the main channels to which all the other sinuses converge. They often differ in size upon the two sides of the head. They commence at the internal occipital protuberance and curve outward and downward and inward to the jugular foramina, being received in the grooves of the occipital and temporal bones and included in folds of the tentorium. In their course they receive veins from the cerebellum and from the occipital diploic veins, and are joined by the petrosal sinuses. They also communicate with the veins of the scalp by *emissary veins* through the mastoid foramina, and sometimes by the posterior condyloid foramina. It is owing to this intercommunication that many cerebral affections are relieved by counter-irritation, or the application of leeches, in this region. The *superior longitudinal sinus* (Plates 4 and 12) is formed by a separation of the layers of the falx cerebri in the line of the sagittal suture. It commences at the foramen cæcum in front of the crista galli of the ethmoid bone, and passes backward, gradually becoming larger, until it reaches the internal occipital protuberance. At this point the sinus deviates, usually to the right side. It becomes dilated and terminates in the corresponding lateral sinus. The dilatation has long been known as the *torcular Herophili*, or confluence of the sinuses (Plate 4, Fig. 1, No. 12).

A transverse section of the superior longitudinal sinus is found to be triangular, with the base of the triangle upward against the skull (Plate 11, Fig. 1, No. 1). Its lower angle is bridged across at intervals by slender fibrous cords, called *chordæ Willisii.* This sinus receives blood from numerous veins from the adjacent cancellous structure of the skull-cap, from several large veins from each hemisphere of the cerebrum, and through a venous link by means of the parietal foramen from the veins of the scalp. These veins usually enter the walls of the sinus obliquely, passing from behind forward (Plate 4, Fig. 1) in a direction contrary to that of the blood-current in the sinus, probably to prevent regurgitation of blood into the cerebral veins. Very frequently there is a communication between the veins of the nasal fossæ and the apex of the sinus, and in some cases of severe epistaxis the sinus has been supposed to be tapped through such a connection.

The superior longitudinal sinus, from its position, is often subjected to wounds in fracture of the skull, and less frequently in trephining. The hemorrhage resulting is by no means so serious as to warrant great alarm, for there are many recorded cases where such hemorrhage has been easily controlled by gentle pressure. Observation has led to the supposition that the blood circulates more slowly in the sinuses than in the ordinary veins; and their construction seems to be especially for venous receptacles into which a reflux of blood can take place without exercising compression upon the brain-substance. The *cavernous sinuses* are the only other sinuses of importance, and that because of their intimate relations with the internal carotid arteries. Owing to these relations, arterio-venous aneurism sometimes follows injury to the base of the brain. The cavernous sinuses are truly venous plexuses situated at the sides of the body of the sphenoid bone, surrounding the carotid arteries. They receive blood from the anterior inferior cerebral veins, and through the ophthalmic veins from the orbits. This latter communication may lead to thrombosis of the sinuses by extension of inflammation from disease within the orbits along the ophthalmic veins. The cavernous sinuses empty their blood by means of the upper and lower petrosal sinuses into the lateral sinuses.

The *nerves of the dura mater* are the recurrent branches of the fourth and some filaments from the fifth of the cranial nerves. Besides these there have been demonstrated upon the dura filaments from the ophthalmic and hypoglossal nerves, as well as some from the sympathetic nerve.

PLATE 3.

Figure 1.

The base of the skull seen from within, showing the exits of the cranial nerves. The dura mater lining the fossæ of the skull is retained, surrounding and forming sheaths for all the nerves which are left *in situ* after the removal of the brain. (From a female head, aged twenty-one years.)

1. The left olfactory bulb (or first cranial nerve).
2. The left optic nerve (or second cranial nerve).
3. The left internal carotid artery.
4. The optic chiasm.
5. The motor oculi nerve (or third cranial nerve).
6. The trochlearis nerve (or fourth cranial nerve).
7. The trifacial nerve (or fifth cranial nerve).
8. The abducent nerve (or sixth cranial nerve).
9. The facial nerve (or seventh cranial nerve); and the auditory nerve (or eighth cranial nerve).
10. The hypoglossal nerve (or twelfth cranial nerve).
11. The glosso-pharyngeal nerve (or ninth cranial nerve).
12. The pneumogastric nerve (or the tenth cranial nerve).
13. The spinal accessory nerve (or eleventh cranial nerve).
14. The crista galli of the ethmoid bone.
15. The right frontal fossa.
16. The olivary process of the sphenoid bone.
17. The right internal carotid artery.
18. The temporal fossa.
19. The basilar portion of the occipital bone, joining that of the sphenoid.
20. The right occipital fossa.
21. The internal occipital crest.
22. The internal occipital protuberance.

Figure 2.

The distribution of the branches of the trifacial (or fifth cranial nerve), and their relation to the arteries of the face.

1. The supra-orbital nerve.
2. The supra-trochlear nerve.
3. The infra-trochlear nerve.
4. The terminal branches of the lachrymal nerve.
5. The infra-orbital branch of the superior maxillary nerve.
6. The spheno-palatine (sympathetic) ganglion (or Meckel's ganglion).
7. The descending palatine nerves.
8. The infra-orbital nerve and artery.
9. The anterior and posterior dental nerves and arteries.
10. The superior buccal nerve.
11. The inferior buccal nerve.
12. The inferior dental nerve and artery.
13. The mental nerves and artery.
14. The optic nerve.
15. A nasal branch from the infra-orbital nerve.
16. The position of the Vidian nerve.
17. The branches of the inferior maxillary nerve to the muscles of mastication.
18. The ophthalmic nerve (or first division of the trifacial nerve).
19. The anterior branch of the temporal artery.
20. The auriculo-temporal nerve.
21. The posterior branch of the temporal artery.
22. The temporal artery.
23. The middle meningeal artery.
24. The chorda-tympani nerve.
25. The internal maxillary artery.
26. The occipital artery.
27. The posterior auricular artery.
28. The facial nerve.
29. The lingual nerve (or gustatory nerve).
30. The chorda tympani nerve, where it joins with the lingual nerve.
31. The infra-maxillary branch of the facial nerve.
32. The external carotid artery.
33. The internal carotid artery.
34. The common carotid artery.
35. The facial artery.

Figure 3.

The posterior view of a European skull (*the norma occipitalis*). Showing remarkable Wormian bones (or *ossa triquetra*). Nos. 4 and 13.

1. The sagittal suture.
2. The left parietal foramen.
3. The left parietal eminence.
4. The left side of the upper portion of the occipital bone (Wormian).
5. The lambdoid suture.
6. The left asterion.
7. The external occipital protuberance (*the inion*).
8. The left mastoid process.
9. The digastric groove.
10. The obelion.
11. The right parietal eminence.
12. The lambda.
13. The right side of the upper portion of the occipital bone (Wormian).
14. The right asterion.
15. The right mastoid process.
16. The occipital crest.

Figure 4.

The right side of a skull of an adult male, with the outer table rasped away to show the diploic veins.

1. The fronto-parietal veins, which communicate with the superior petrosal sinus.
2. The external parietal veins, which terminate usually in the mastoid vein.
3. The parieto-occipital veins emptying into the lateral sinus.
4. The frontal veins, which communicate with the supra-orbital veins.
5. The fronto-sphenoidal veins, which connect with the deep temporal veins.

Figure 5.

Oblique section through the left temporal bone, to show the tympanic cavity and mastoid cells on one side, and on the other the membrana tympani, the ossicles, and the Eustachian tube.

1. The position of the squamo-petrosal suture.
2. The eminence over the semicircular canals.
3. The depression for the Gasserian ganglion of the fifth cranial nerve on the apex of the petrous bone.
4. The internal carotid artery entering its canal.
5. The tympanic cavity.
6. The pyramid for the stapedius muscle.
7. The stapes resting on the fenestra ovalis.
8. The fenestra rotunda.
9. The aqueduct of Fallopius.
10. Section through the mastoid cells.
11. The squamous portion of the temporal bone.
12. The position of the canal of Huguier.
13. The tensor tympani muscle.
14. The end of the manubrium of the malleus.
15. The osseous portion of the Eustachian tube.
16. The incus.
17. The membrana tympani.
18. The styloid process.
19. The mastoid process.

Fig 1

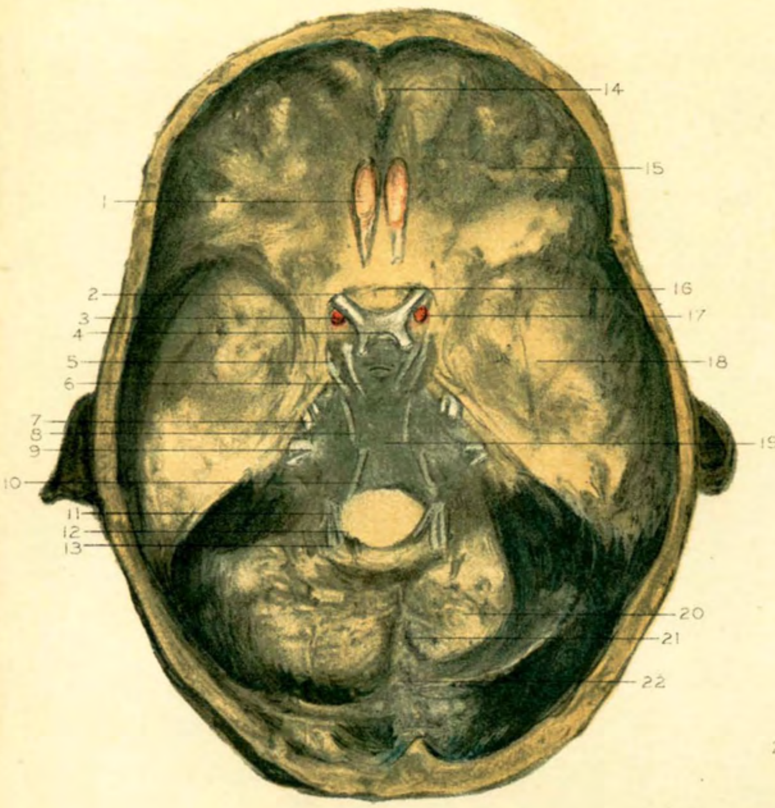


Fig 2

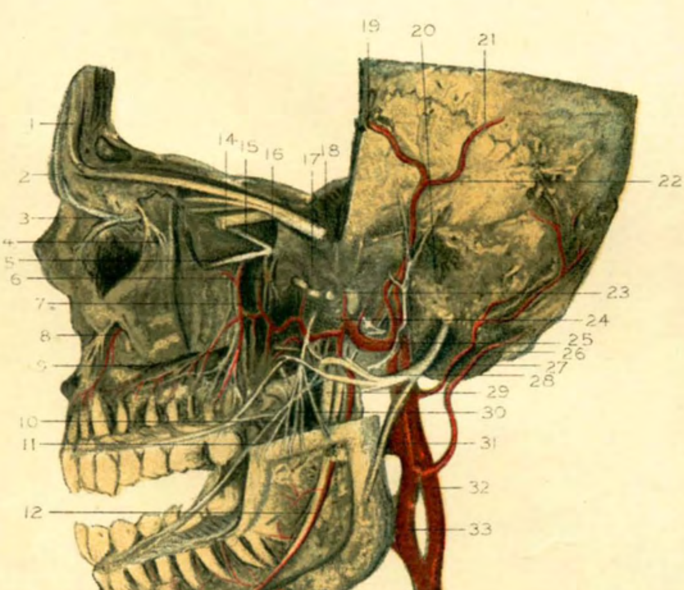
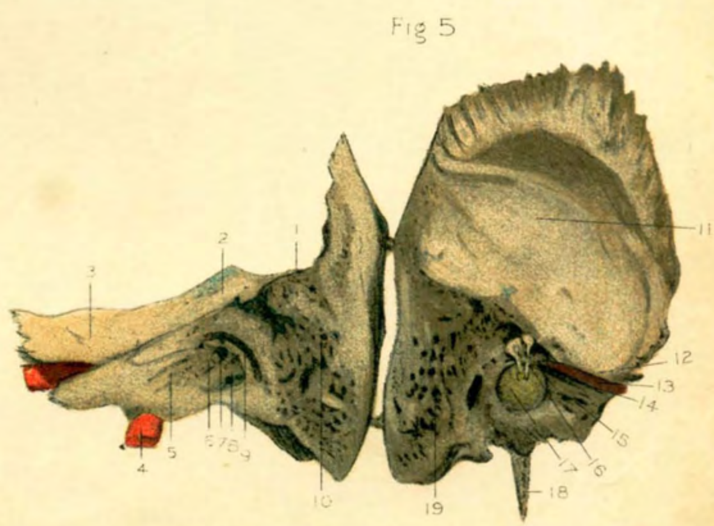


Fig 3

Fig 4

Fig 5



Dissected, Photographed and Colored from Nature by George Mc. Clellan, M.D.

Armstrong & Co. Lith. Boston.

The cerebral surface of the dura mater is lined by the delicate **arachnoid membrane** (Plate 5, Fig. 1), which in the normal state facilitates the pulsations of the underlying convolutions, owing to its property of secreting a serous fluid. The amount of fluid between the dura and the arachnoid tissue is inconsiderable. It is contained within the *sub-dural space,* so called in contradistinction to the *sub-arachnoid space,* which is between the arachnoid membrane and the subjacent vascular tissue,—the *pia mater.* The arachnoid membrane is colorless and extremely thin over the upper surface of the hemispheres, but it becomes thicker at the base of the brain in front and behind the pons Varolii, where it is opaque. At these localities there is always a quantity of serous fluid which serves to support the overlying brain. The arachnoid fluid passes into the interior ventricular cavities of the brain by means of the opening into the fourth ventricle for the *choroid tela* (Magendie's foramen), and thus serves to exert a sustaining pressure both within and without, thereby preventing the ill effects of concussion, and enabling one hemisphere to support the weight of the other when the head rests upon the side. The arachnoid membrane does not unite with the dura except where the cerebral veins pass to the sinuses or around the corpora Pacchioni, and it does not accompany the pia mater into the sulci between the convolutions. The *arachnoid* or *cerebro-spinal fluid* is a limpid liquid with a salty taste and a slightly alkaline reaction. In cases of fracture of the base of the skull, involving the petrous portion of the temporal bone, the escape of the cerebro-spinal fluid through the ear is a diagnostic feature, as previously stated.

The pia mater is a delicate net-work of connective tissue in immediate relation to the surface of the brain, containing within its meshes the ramifications of the cerebral vessels. It closely follows the infolding of the brain-surface, which constitutes the convolutions, and lines the great fissures which characterize the development of the organ, and by some of them is continued into the ventricular cavities. After removal of the dura mater many large superficial veins will be noted passing between the layers of the pia mater to empty their blood into the sinuses (Plate 5, Fig. 1, and Plate 10, Fig. 1). They do not regularly accompany the arteries, and on the surface of the hemispheres they freely communicate with one another. At the base of the brain the pia mater becomes more dense and fibrous, investing the cerebral crura, the pons, and the medulla oblongata. Here the contained arteries divide into groups of *long* vessels which penetrate the brain-substance and give rise to the *anterior* and *posterior perforated spaces*.

The arteries of the brain are derived from the two *internal carotid arteries*, which enter the base of the skull through the carotid canals in the temporal bones, and from the two *vertebral arteries*, which, after ascending through the foramen magnum, unite to form the *basilar artery* on the surface of the pons. These main sources which furnish the blood to the brain pursue a tortuous course (Plate 3, Fig. 5, and Plate 4, Fig. 2) before they gain entrance into the calvarium, and immediately afterward are disposed in a remarkable inosculation (the circle of Willis) (Plate 5, Fig. 3), for the purpose of equalizing and moderating the flow of the blood in the several parts of the brain. The *internal carotid artery* is surrounded by the *cavernous plexus of veins* by the side of the body of the sphenoid bone, and branches into the ophthalmic, anterior, and middle cerebral, posterior communicating, and anterior choroid arteries. The *anterior* and *middle cerebral arteries* arise from the internal carotid at the inner end of the fissure of Sylvius. The former passes to the longitudinal fissure, where it is joined to its fellow from the opposite side by the *anterior communicating artery;* thence the two anterior cerebral arteries run side by side, supplying the adjacent frontal lobes and corpus callosum. The middle cerebral is the largest branch of the internal carotid (Plate 5, Fig. 3, No. 18). After giving off numerous small branches to the anterior perforated space to go to the corpus striatum, it penetrates deeply into the fissure of Sylvius, furnishing the anterior and middle lobes of the hemisphere. The anterior choroid branch of the internal carotid passes, by means of the slit (the hippocampal fissure) in the middle horn of the lateral ventricle, to the choroid plexus. The *posterior communicating artery* is often of unequal size (Plate 5, Fig. 3) on the two sides, and passes backward to join the posterior cerebral artery from the basilar, thus completing the arterial chain at the base of the brain.

The branches from the posterior cerebral arteries communicate with those from the anterior and middle cerebral. Before the vertebral arteries join to form the basilar they give off small branches in the neighborhood of the medulla oblongata to the contiguous parts, meningeal and spinal branches, and the posterior cerebellar artery on each side. The other cerebellar arteries arise from the basilar. The *basilar artery* also gives off transverse twigs (Plate 5, Fig. 3) as it lies in the median groove on the pons, the *auditory artery,* accompanying the auditory nerve, being one of them. The vessels which penetrate into the brain are accompanied by delicate sheaths from the pia mater, which serve as lymphatic channels communicating with the sub-arachnoid and sub-dural spaces, the great cerebral lymph-spaces.

The chief routes by which the pia mater conveys its capillary meshes into the brain-cavities are by the *transverse fissure,* as the *choroid tela,* into the lateral and third ventricles, and along the roof of the fourth ventricle, forming the *velum interpositum* and *choroid plexus.*

The free intercommunication from side to side of the arteries at the base of the brain is most important, as there is no anastomosis between the arteries of the cortical surface and the arteries of the ganglionic masses. Softening of the brain probably ensues upon inadequate collateral circulation of these vessels, whether due to a pathological or to a traumatic condition. Recently it has been shown that there are special systems of nutrient arteries derived from the circle of Willis, the *central* or *ganglionic* and the *peripheral* or *cortical arteries.* These systems are independent of each other, and their *terminal arteries* (*of Cohnheim*) do not anastomose.

The most noteworthy group of vessels of the ganglionic system are the branches from the middle cerebral artery which penetrate the anterior perforated space to supply the corpus striatum and optic thalamus on each side. A particular branch, the *lenticulo-striate artery,* so called because of its distribution to the lenticular and caudate nuclei, is often the source of cerebral hemorrhage. The cortical arteries are peculiar in their mode of origin, being adapted to the immediate supply of blood to the brain-tissue. They arise directly from the larger arteries in minute branches, which take a vertical or an oblique course, according to their destination, those on the upper border of a convolution being vertical, and those on the sides passing obliquely. Those which penetrate the layers of cortical gray matter to the centrum ovale are the *medullary capillaries*, and vary from three to five centimetres, or from one to two inches, in length. These are the terminal arteries proper. In consequence of the independence of these cerebral capillary systems, many localized lesions, arising from emboli obstructing the blood-current, can be recognized and explained during life. Such a lesion may be limited to an area involving a special function, especially in the region supplied by the branches of the middle cerebral artery,—*i.e.*, the motor centres and the faculty of speech.

As elsewhere in the body, the principal vessels are supplied with *sympathetic nerves*, and these form in the head intricate plexuses mainly around the internal carotid arteries at the base of the brain.

After removal of the pia mater, the brain-mass, with its furrows and convolutions, is exposed directly to view (Plate 10, Fig. 2). If the organ is retained within the skull, the proper relations which the surface-markings of the brain bear to the overlying structures can be profitably studied; and, as the subject of *cranio-cerebral topography* has now attained great importance, owing to the recent development of intra-cranial surgery, it will receive especial attention.

In order that a clearer comprehension of this difficult and complex region may be obtained, a succinct description of the surface anatomy of the brain removed from the head will be given before explaining its application.

The brain (encephalon) is that portion of the central nervous system which is contained within the cranium, and consists of the cerebrum, cerebellum, pons, and medulla oblongata. The cerebrum overlies the other portions of the brain, occupying the whole of the upper part of the cranial cavity. Its base rests on the anterior and middle fossæ of the skull, and posteriorly it is separated from the cerebellum by the *tentorium*, the arching transverse fold of the dura mater. The cerebellum occupies the occipital fossæ. The pons (Varolii) rests upon the basilar process and body of the sphenoid bone, and is connected with the cerebrum by the crura cerebri, and with the cerebellum by the crura cerebelli. The medulla oblongata is the portion below the pons, and rests upon the basilar process of the occipital bone. It is continuous with the spinal cord.

The brain conforms in size and shape with the interior of the skull, or brain-case. Its mass is to some extent related to the size of the body, and it is modified by the degree of mental development of the individual to whom it belongs, the intelligence probably depending upon the quality rather than upon the quantity of the organ. During intra-uterine life the *development of the brain* is very active, and at birth it is relatively of large size, of a soft pulpy consistence, presenting an approximation in form and relations to the adult brain. It grows rapidly up to the seventh year, becoming gradually firmer, and from that period until about the age of forty it increases very slowly. Its full growth is considered to have been attained between forty-five and fifty years of age. The average weight of the brain in males is forty-nine ounces; in females, forty-four ounces. In old age it decreases in a measure commensurate with the waning of the faculties. The brain consists of gray and white neural tissue variously disposed, the gray matter, composed mainly of *nerve-cells*, being arranged on the cortical surface, and in the ganglionic masses at the base of the organ; the white matter, made up of *nerve-fibres*, being within, and serving to connect the gray portions and to bring them into relation with the spinal cord through the pons and medulla. The gray matter on the cortical surface is arranged in several layers of various forms of cells, which are intimately surrounded with numberless capillary vessels from the adjacent pia mater. These cells are connected through their prolongations with the nerve-fibres of the white substance. The minute structure of the nerve-cells and nerve-fibres is described with the anatomy of the spinal cord in Vol. II.

The whole brain is partially divided into symmetrical halves by a median fissure extending from before backward. The *area of the surface of the brain* is greatly extended by the cortical gray matter being irregularly raised in tortuous convolutions (*gyri*) or involuted into furrows (*sulci*), so that, with great economy of space, its actual surface is nearly six times what it would be were it merely a smooth envelope. The number of convolutions and the depth of the furrows between them vary in different brains, and consequently the extent of the gray surface-matter upon which the intellectual capacity depends is variable.

All physical and moral actions have their perceptive centres somewhere in the cortical substance of the cerebrum. An animal may live after removal of its cerebral hemispheres, but it will be insensible to peripheral disturbance and incapable of exercising volition. The anterior portions of the hemispheres are without sensibility, as is manifest in cases of wounds in which they have been injured.

The cerebrum consists chiefly of two lateral masses, called, from their shape, *hemispheres*, which are partially separated by the falx cerebri of the dura mater being received into the great longitudinal fissure between them. At the bottom of this fissure a band of white transverse nerve-tissue connects the two hemispheres: this band, owing to the decussation of its component fibres, is known as the *commissure of the cerebrum*, or the *corpus callosum* (Plate 11, Fig. 1, No. 8).

The hemispheres are not always of equal size, as the longitudinal fissure is not always placed exactly in the middle line (Plate 6, Fig. 1). The left hemisphere has generally been found to be larger than the right, and this has been attributed to the more direct blood-supply to the brain on that side, through the left vertebral and common carotid arteries, the latter arising independently from the arch of the aorta. The right hemisphere is often, however, larger than the left (Plate 6, Fig. 1) in a brain otherwise normally developed. Each hemisphere consists of an *anterior* (*frontal*), a *middle* (*temporo-sphenoidal*), and a *posterior* (*occipital*) *lobe*, which are best seen on the under surface, and correspond to their respective positions in the fossæ of the cranium. Besides these there are the *parietal lobe*, placed between the *frontal* and the *occipital lobe*, on the lateral and upper surface, and the *central lobe*, situated within the fissure of Sylvius, at the base of the brain.

The disposition of the convolutions and furrows on the surfaces of the two hemispheres is not identical, owing to the varying development of the several localities. It is, therefore, improbable that any definite area will always possess the same group of nerve-cells, for they may be on the surface of a convolution in one brain, and in an adjacent furrow in another, depending upon the relative growth of the locality. The *primary fissures* of the cerebral hemispheres—viz., the Sylvian, hippocampal, parieto-occipital, and calcarine—appear during the third month of fœtal life. The *secondary fissures*, the most important being the fissure of Rolando, appear between the fifth and sixth months. The further development of the fissures, and consequently of the convolutions, occupies the last two months of fœtal life and the first five or six weeks after birth, at which time the cerebral surface can be clearly mapped out. The largest and most complicated convolutions characteristic of the *human* brain are upon the *upper* surface of the hemispheres, frequently branching toward the longitudinal fissure in their course like the letter **Y**. They do not exactly correspond upon the two sides. The most important of the convolutions on the external surface of the hemispheres are the central, or parietal, convolutions, which are always the most perfectly developed in all animals whose brains are convoluted. They occupy approximately the same relative position on each side of the brain, and are separated by the deep fissure of Rolando or central fissure (Plates 6 and 7). The area surrounding this fissure has been satisfactorily proved by physiological research and pathological facts to involve the principal motor functions of the body (Plate 2, Fig. 2, and Plate 10, Fig. 2).

The *fissure of Rolando* (Plate 6, Fig. 1, Nos. 3 and 13, and Plate 7, Figs. 1 and 2, No. 1) usually begins close to the longitudinal fissure, about its middle, on the upper surface, and runs obliquely over the outer convex surface of the hemisphere downward and forward, until within a short distance of the fork of the *Sylvian fissure*. The lesser wing of the sphenoid bone is lodged within the fissure of Sylvius. This fissure begins (Plate 6, Fig. 2, No. 6) in a depression called the *vallecula*, at the anterior perforated space at the base of the cerebrum, and passes outward as a deep cleft (Plate 7, Fig. 1, No. 22), which divides into an ascending or *vertical* branch two centimetres, or a little less than an inch, in length, and a *horizontal* branch, which passes backward and curves slightly upward. It usually terminates in the parietal lobe in a *bifid* extremity. At the point where these branches originate, a third branch passes transversely, and is hidden within the substance of the brain. The branches

PLATE 4.

Figure 1.

The right hemisphere of the cerebrum removed to show the falx cerebri and tentorium of the dura mater, and the relations of the great sinuses and their tributaries. (From the same head as in Plates 9 and 10.)

1. The cut tissues of the scalp.
2. The outer table of the skull-cap.
3. The diploic structure.
4. The inner table of the skull-cap.
5. The superior longitudinal sinus.
6. The inferior longitudinal sinus.
7. The falx cerebri.
8. One of the posterior tributary veins.
9. The venæ Galeni.
10. The straight sinus.
11. The tentorium cerebelli.
12. The position of the torcular Herophili.
13. One of the anterior tributary veins.
14. The convolution of the corpus callosum of the left hemisphere.
15. The apex of the longitudinal sinus passing to the foramen cæcum.
16. The artery of the corpus callosum.
17. The crista galli of the ethmoid bone.
18. The corpus callosum.

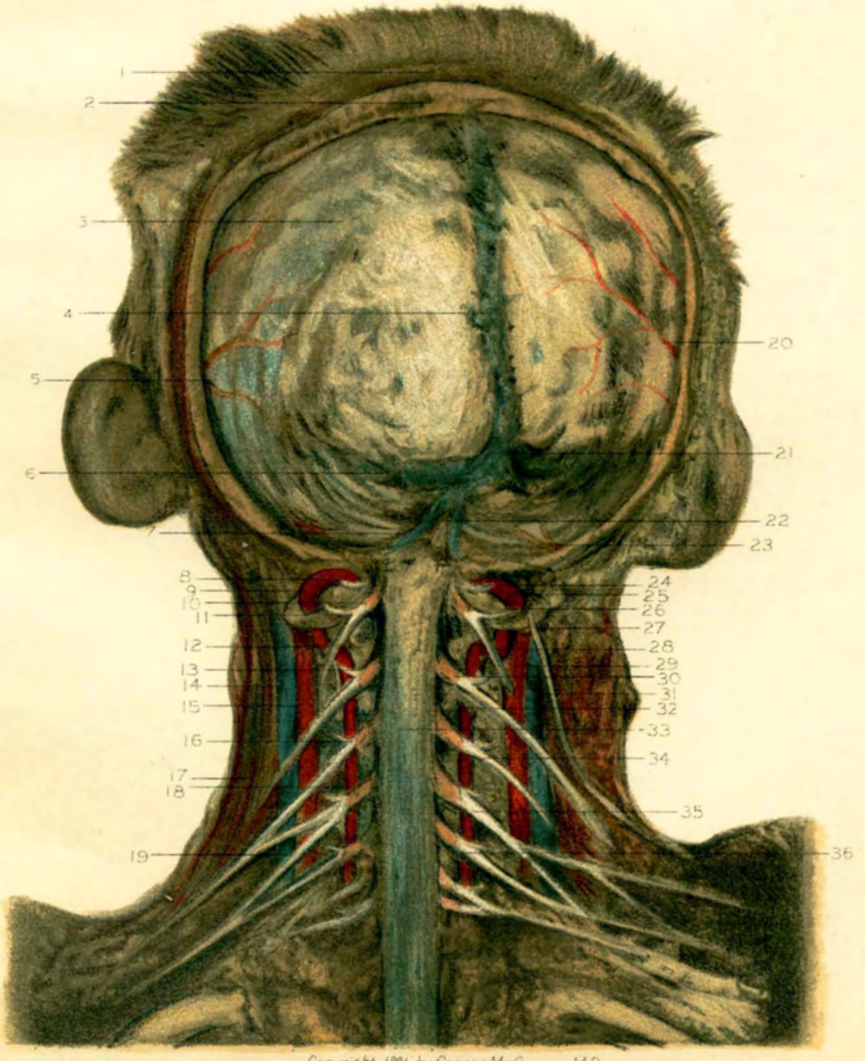
Figure 2.

The posterior third of the skull and its scalp removed to show the posterior view of the dura mater, and the confluence of the lateral and occipital sinuses with the superior longitudinal sinus. Also the posterior segments of the cervical vertebræ are removed to show the continuation of the dura mater of the brain with that of the spinal cord, the ganglions on the posterior roots of the cervical nerves, and the course of the vertebral arteries through the vertebral foramina.

1. The cut tissues of the scalp.
2. The section of the parietal bones at the sagittal suture.
3. The dura mater over the posterior lobe of the left hemisphere of the cerebrum.
4. The great, or superior, longitudinal sinus.
5. The posterior branches of the left middle meningeal artery.
6. The left lateral sinus.
7. The left occipital sinus.
8. The left sub-occipital (or first cervical nerve).
9. The left vertebral artery curving upon itself before entering the foramen magnum.
10. The ganglion on the posterior root of the second cervical nerve.
11. The left transverse process of the atlas vertebra.
12. The descending branch of the posterior division of the second cervical nerve, passing to the third.
13. The ganglion on the posterior root of the third cervical nerve.
14. The left internal jugular vein.
15. The left common carotid artery.
16. The ganglion on the posterior root of the fourth cervical nerve.
17. The left sterno-cleido mastoid muscle.
18. The ganglion on the posterior root of the fifth cervical nerve.
19. The left brachial plexus of nerves.
20. The posterior branches of the right middle meningeal artery.
21. The right lateral sinus.
22. The right occipital sinus.
23. The right posterior meningeal artery.
24. The right sub-occipital (or first cervical nerve).
25. The right vertebral artery at its curvature.
26. The occipitalis major nerve (or internal branch of the posterior division of the second cervical nerve).
27. The right spinal accessory nerve.
28. The descending branch of the second cervical nerve.
29. The right common carotid artery.
30. The ganglion on the posterior root of the third cervical nerve.
31. The right internal jugular vein.
32. The right vertebral artery.
33. The dura mater of the spinal cord.
34. The right fourth cervical nerve.
35. The right fifth cervical nerve.
36. The right brachial plexus.

Fig 1

Fig 2



Dissected, Photographed and Colored from Nature by George Mc Clellan, M.D.

Armstrong & Co. Lith. Boston.

of the fissure of Sylvius originate from the development of the hemisphere around the *central lobe* (or *insula*), which is usually covered in (Plate 7, Fig. 1), but is occasionally visible (Plate 7, Fig. 2, No. 7). The portion of the hemisphere overlapping the central lobe is called the *operculum*, from its lid-like character. The fissure of Sylvius is the most conspicuous of the cerebral fissures, and is easily recognizable. The *parieto-occipital fissure* is seen on the median surface (Plate 8, Fig. 1, No. 5, and Fig. 2, No. 20). It begins at the calcarine fissure near the corpus callosum, and ascends vertically, ending on the external surface, about an inch beyond the longitudinal fissure. It partially defines the parietal and occipital lobes, and occasionally blends with the horizontal branch of the Sylvian fissure. The *calcarine fissure* (Plate 8, Fig. 1, No. 7, and Fig. 2, No. 23) begins near the posterior border of the hemisphere and passes forward, receiving the parieto-occipital fissure midway, and ends under the corpus callosum, penetrating into the posterior horn of the lateral ventricle, dividing the hippocampal convolution.

The *hippocampal fissure* extends from the gyrus fornicatus to the hippocampal hook. The *fascia dentata* projects inwardly through this fissure, over which the *pia mater* passes to join with the choroid plexus of the lateral ventricle.

The *transverse fissure* (*of Bichat*) is the breach between the cerebrum and the cerebellum (Plate 7, Fig. 1, No. 12). This fissure is due to the cerebral hemispheres being folded backward over the thalamic region, and it admits the pia mater into the interior of the brain as the velum interpositum.

The *interparietal fissure* (Plate 7, Fig. 1, No. 5, and Fig. 2, No. 20) is the most important of the secondary furrows on the parietal portion of the hemisphere. It is very variable in form and position, sometimes being connected with the parieto-occipital and sometimes with the horizontal branch of the Sylvian fissure. Generally it begins between the latter and the Rolandian fissure, and curves backward somewhat parallel with the superior border of the cerebrum.

It will be noticed that the character of nearly all the great fissures which separate the cortical surface into lobes is variable. This is even more so with regard to the smaller (*intra-lobular*) fissures between the convolutions in the different lobes of the hemispheres. The changes in the position of these furrows probably depend upon the variability of the development of their localities in different brains.

The *frontal lobe* (Plate 6, Fig. 1, No. 2) consists of the cerebral surface situated in front of the fissure of Rolando and over the fissure of Sylvius. This lobe is divided by furrows (the *frontal sulci*) into four principal convolutions (the *frontal gyri*), which are subdivided into secondary convolutions by modifications of their arrangement and connections. The frontal convolutions are the superior, middle, and inferior, and the anterior central (Plate 7, Fig. 2, Nos. 2, 3, 4, and 5). The *superior frontal convolution* (Plate 7, Fig. 1, No. 15) is in relation to the longitudinal fissure, borders on the anterior part of the corpus callosum internally, and extends to the under surface, where it is known as the *olfactory convolution*, from its reception of the olfactory bulb in a depression (Plate 6, Fig. 2, No. 2). The adjacent *middle frontal convolution* (Plate 7, Fig. 1, No. 17) also extends to the under surface, and is there called the *orbital convolution*. The *inferior frontal convolution* (Plate 7, Fig. 1, No. 19) is below the preceding and in relation to the Sylvian fissure. It is now often called *Broca's convolution*, or the *speech centre*, from the localization of the movements of the lips and tongue, in articulation, in its posterior portion.

The *anterior central* or *ascending frontal convolution* (Plate 7, Fig. 1, No. 14) is separated from the three frontal convolutions by the posterior frontal (or *vertical*) furrow (Plate 7, Fig. 1, No. 16), and it usually blends with the upper and lower frontal convolutions, and with the posterior central convolution, curving round the ends of the *central fissure* of Rolando.

The *parietal lobe* occupies the upper and lateral portions of the hemisphere between the fissure of Rolando and the external part of the parieto-occipital fissure, and is over the horizontal branch of the fissure of Sylvius. There are three principal convolutions on the outer surface of this lobe,—the posterior central and the superior and inferior parietal convolutions.

The *posterior central* or *ascending parietal convolution* is, as before stated, ordinarily continuous with the anterior central or ascending frontal. The two convolutions thus completely surround the fissure of Rolando (on the cortical surface), and the area thus formed is called the *opercular lobe* (Plates 6 and 7). The connecting portion above the fissure of Rolando is the *para-central lobule,* and that below it is the *infra-central lobule.* The latter region is considered to be correlated with the movements of the head and face, while those of the arm and hand are referred to the middle portions of the anterior and posterior central convolutions, and those of the leg and foot to the para-central region.

The *superior* and *inferior parietal convolutions* are separated by the inter-parietal fissure (Plate 7, Fig. 2, No. 20), and are usually continuous with the convolutions of the occipital lobe by bridges of gray matter called the *annectent convolutions.*

Both of the parietal convolutions are variously subdivided. The *inferior* is very tortuous, and commonly consists of two chief portions, the *superior marginal* and the *angular convolution.* The former usually blends with the lower part of the posterior central convolution and arches over the end of the horizontal branch of the Sylvian fissure to join the superior temporal convolution. The *angular convolution* (Plate 7, Fig. 1, No. 7) is behind the supra-marginal and parallel with the Sylvian fissure. It usually joins the middle temporal convolution by means of the two lower annectent convolutions. Upon the median surface the superior parietal convolution joins with the upper extremity of the posterior central convolution to form the *præcuneus,* or *quadrate lobule* (Plate 8, Fig. 2, No. 18), which is continuous with the convolution of the corpus callosum.

The *occipital lobe,* also variously subdivided, presents three principal convolutions, superior, middle, and inferior, which are subdivided by the occipital fissures and continuous with the convolutions of the parietal and temporal lobes. Upon the median surface the superior occipital convolution, somewhat triangular in shape, forms the *cuneus lobule,* placed between the parieto-occipital fissure and the calcarine fissure.

The surface of the occipital lobe which rests upon the tentorium is composed chiefly of two convolutions, the inner one of which blends with the hippocampal convolution and the outer one is the occipital part of the *occipito-temporal convolution.* They are both continuous with the convolutions on the under surface of the temporal lobe. The *temporal lobe* (*temporo-sphenoidal*) presents on its outer surface generally three defined convolutions, superior, middle, and inferior, separated by variously arranged temporal fissures, and connected, as above stated, with the parietal and occipital convolutions.

The *hippocampal convolution* is separated from the occipito-temporal convolution, on the under surface, by the *collateral fissure.* It forms the floor of the middle horn of the lateral ventricle, terminating in the *hippocampal hook* (*processus unciformis*). The calcarine fissure divides the hippocampal convolution at the back part of the corpus callosum.

The *central lobe, island of Reil,* or *insula,* as it is variously known, is situated within the fork of the Sylvian fissure, where it is occasionally partially visible on the external surface (Plate 7, Fig. 2, No. 7), and is overlapped by the operculum. It consists of from four to six small convolutions (the *gyri operti*), arranged side by side upon a triangular mass, and appearing, when exposed, very much like the fingers of the hand when closed upon the palm. These convolutions are the first to appear in the fœtus and among animals, and are gradually enclosed by the other principal convolutions developing around them.

Behind the central lobe there are usually several small convolutions, known as the *temporo-parietal* or *retro-insular convolutions.* They bridge over the temporal and parietal lobes. The *fornicate convolution,* or *convolution of the corpus callosum,* which is to be seen on the median surface (Plate 8, Fig. 1, No. 16), extends round the upper surface of the corpus callosum, beginning at the anterior perforated space, and blending behind with the uncinate convolution below the quadrate lobule.

Cranio-Cerebral Topography.—In the description of the landmarks of the head the relations which the external parts of the cranium bear to the surface-coverings are stated in detail. The topographical survey of the skull is here considered in its relation to the brain (Plate 9, Fig. 1).

The points on the outer surface of the calvarium which bear upon the position of the principal fissures of the brain cannot always be definitely determined through the scalp, even though the head be shaved; and the most careful observation, or calculation based on statistics of measurements, cannot insure accuracy, for no two heads are precisely alike in their conformation and the arrangement of their contents.

Only *approximative* results can be obtained by deducing from the landmarks of any skull the relative positions of the parts of the brain which it contains. A line drawn across the forehead above the eyebrows in front, and along the side of the head, two centimetres, or a finger's breadth, above the external angular process of the orbit, to the root of the zygomatic process and thence to the external occipital protuberance, corresponds in a measure to the *lower level of the cerebrum* (Plate 2, Fig. 1); the cerebellum occupies the space below the latter portion of this line, but its lower level cannot be defined externally, as it depends upon the extent to which the lower occipital fossæ project at the nape of the neck. The *frontal* and *parietal eminences* seem to indicate the proportionate development of the frontal and parietal lobes of the cerebrum. The parietal eminence corresponds to the supra-marginal convolution, and the frontal eminence to the superior frontal convolution. The *pterion* is the junction of the great wing of the sphenoid bone with the frontal, parietal, and temporal bones. Here the *fissure of Sylvius* commences. Its short ascending branch is just behind and parallel with the coronal suture, and its long horizontal branch extends upward and backward across the upper margin of the squamo-parietal suture on a line drawn on the side of the head from the nasion to the lambda (Plate 2, Fig. 2, No. 6, and Plate 53, Fig. 1, No. 18). The coronal suture passes from the *bregma,* the junction of the coronal and sagittal sutures, at the top of the head, to the middle of the zygomatic arch. The *lambda* is the junction of the sagittal and lambdoid sutures. The external portion of the parieto-occipital fissure is a little in front of the lambda. The *inion* is the external occipital protuberance. The upper end of the *fissure of Rolando* (Plate 2, Fig. 2, No. 13) begins at or near the middle line five centimetres, or about two inches, behind the coronal suture, or at a point one centimetre, or about half an inch, back from the middle of

PLATE 5.

Figure 1.

The pia mater, with its vessels ramifying over the convolutions on the upper surface of the hemispheres. The longitudinal sinus in position, with clusters of the Pacchionian granules within it and upon either side.

1. The frontal sinus of the skull.
2. The forepart of the longitudinal sinus passing towards the foramen cæcum.
3. The Pacchionian granules in relation to the left side of the longitudinal sinus.
4. The longitudinal sinus of the dura mater.
5. The vessels of the pia mater over the left hemisphere.
6. The longitudinal sinus passing backward to the torcular Herophili.
7. The Pacchionian granules in relation to the right side of the longitudinal sinus.
8. The vessels of the pia mater over the right hemisphere.

Figure 2.

The base of the skull with the cerebellum retained in the occipital fossæ. Portions of the orbital roofs are removed to show the nerves and muscles passing to the eyeballs.

1. The frontal branch of the left ophthalmic nerve.
2. The left supra-trochlear nerve.
3. The left eyeball.
4. The left superior rectus muscle.
5. The nasal branch of the left ophthalmic nerve.
6. The fatty capsule of Tenon.
7. The left external rectus muscle.
8. The left optic nerve, passing into the optic foramen.
9. The left internal carotid artery.
10. The optic commissure.
11. The nerve to the left superior oblique muscle (or fourth cranial nerve).
12. The Gasserian ganglion of the left fifth cranial nerve.
13. The cut end of the left abducent nerve to the external rectus muscle.
14. The left lobe of the cerebellum, showing the superior cerebellar veins.
15. The right eyeball.
16. The right external rectus muscle.
17. The frontal branch of the right ophthalmic nerve.
18. The right superior rectus muscle.
19. The nasal branch of the right ophthalmic nerve.
20. The capsule of Tenon.
21. The right optic nerve.
22. The right internal carotid artery.
23. The pituitary fossa.
24. The nerve to the right superior oblique muscle (or fourth cranial nerve).
25. The Gasserian ganglion of the right fifth cranial nerve.
26. Section through the pons Varolii.
27. The right lobe of the cerebellum.

Figure 3.

The base of the brain, showing the anastomosis of the arteries, called the circle of Willis. (From an adult male.)

1. The arteries of the corpus callosum within the longitudinal fissure.
2. The arteries to the right frontal convolutions.
3. The right anterior cerebral artery.
4. The right fissure of Sylvius.
5. The anterior communicating artery.
6. The optic commissure.
7. The cut end of the right internal carotid artery.
8. The right posterior communicating artery.
9. The right posterior cerebral artery.
10. The basilar artery, resting on the median groove of the pons Varolii.
11. The right superior cerebellar artery.
12. The right inferior cerebellar artery.
13. The right vertebral artery.
14. The anterior spinal artery.
15. The posterior inferior cerebellar artery.
16. The arteries to the left frontal lobe.
17. The left anterior cerebral artery.
18. The middle cerebral artery, within the fissure of Sylvius, which is displayed by separation of the frontal and parietal lobes.
19. The cut end of the left internal carotid artery.
20. The pituitary body (in this case unusually large).
21. The left corpus albicans.
22. The left posterior communicating artery.
23. The left posterior cerebral artery.
24. The left auditory artery.
25. The left posterior cerebellar artery.
26. The left vertebral artery.
27. The medulla oblongata.
28. The external branches of the left posterior cerebellar artery.

Fig 1

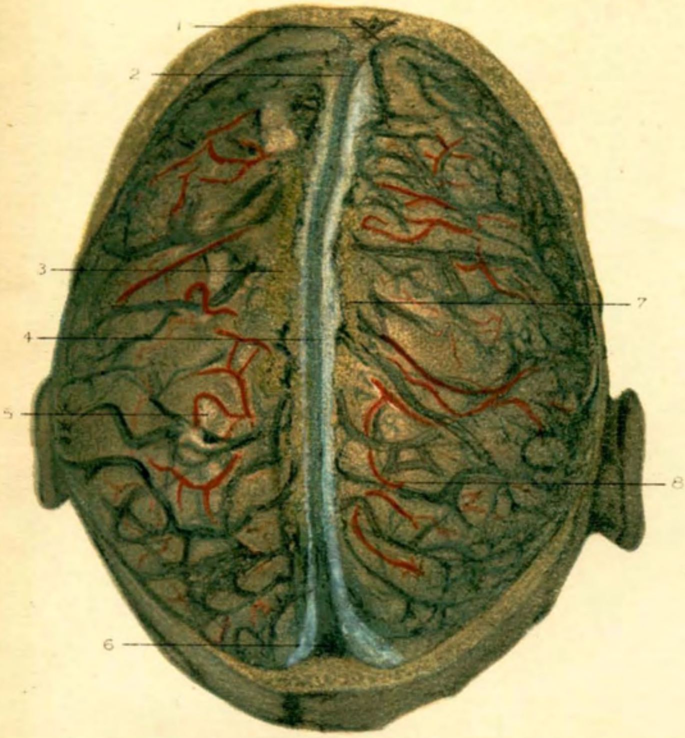
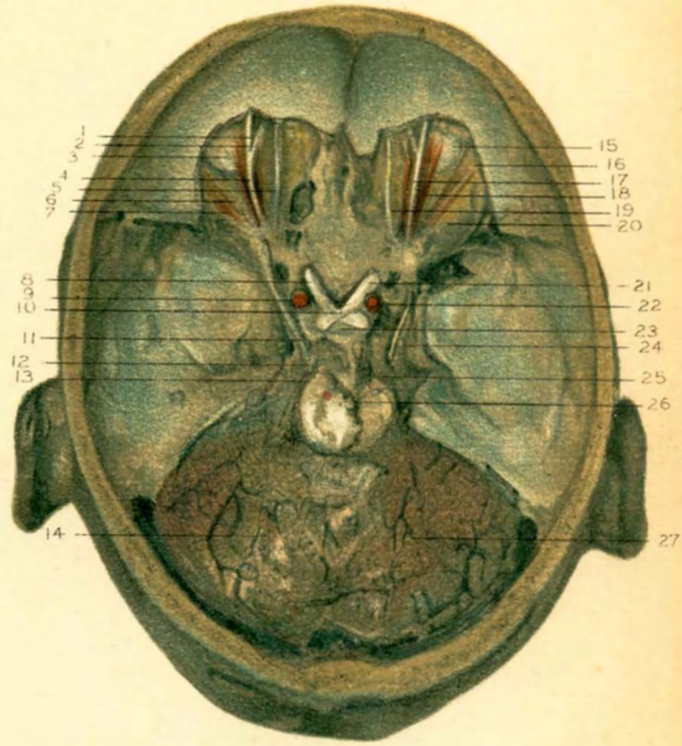


Fig 2



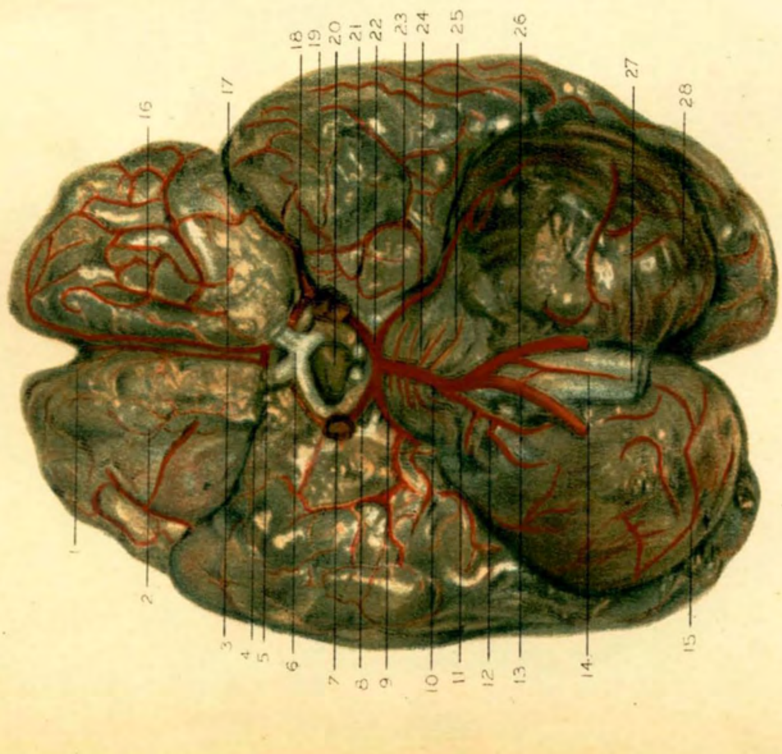


Fig 3

the distance from the *ophryon*, or glabella, to the inion. This fissure passes obliquely downward toward the horizontal branch of the fissure of Sylvius, and its lower end is two and one-half centimetres, or about one inch, behind the coronal suture where it joins the other bones to form the pterion. The *posterior frontal sulcus* (or furrow) is just behind and parallel with the coronal suture (Plate 2, Fig. 2, No. 4). It is sometimes called the vertical sulcus. The ascending frontal convolution is between the posterior frontal sulcus and the fissure of Rolando.

The upper end of the posterior frontal sulcus reaches to about the middle of the fissure of Rolando. The *inferior frontal sulcus* branches off from it about on a level with the *superior stephanion*, which is the point of intersection of the coronal suture and the ridge for the temporal fascia (Plate 2, Fig. 1, No. 5). The *superior frontal sulcus* begins in the upper part of the ascending frontal convolution, over the posterior frontal sulcus, and passes forward and parallel with the inferior. The lower end of the inferior frontal sulcus is separated from the fissure of Sylvius by the *operculum*. The *inter-parietal sulcus* is behind the fissure of Rolando and parallel with the great longitudinal fissure between the hemispheres. It is midway between the latter and the parietal eminence (Plate 2, Fig. 1, No. 12). The *basion* is the middle of the anterior border of the foramen magnum at the base of the skull.

The convolutions in the various regions are designated according to their positions, and their relations are mapped out when the positions of the fissures and sulci are determined.

In seeking to ascertain the function of any locality on the cerebrum, it has been discovered, by means of gentle electrical stimulation, that the so-called *motor cells* are only in the gray matter on the surface, and that faradism of the sides and bottom of the fissures produces no motor reaction.

The area of the *opercular lobe*, which includes the central fissure of Rolando, has been demonstrated to be the controlling centre of the movements of the limbs (Plate 2, Fig. 2, and Plate 10, Fig. 2). This area consists of the following convolutions: the *anterior central* (or *ascending frontal*) *convolution*, in front of the central fissure; the *posterior central* (or *ascending parietal*) *convolution*, behind the central fissure; the *para-central convolution*, which surmounts the central fissure and extends on the median surface of the hemisphere to the calloso-marginal fissure (Plate 8, Fig. 2, No. 17); and the *infra-central convolution*, which separates the central fissure from the horizontal branch of the fissure of Sylvius. The infra-central convolution is correlated with the movements of the face (mouth, lips, tongue, throat, and larynx). Movements of the fingers are produced by stimulation of the cortical surface in the lower portion of the anterior central convolution, and movements of the thumb by stimulation of the corresponding portion of the posterior central convolution. The centre for the wrist is just above the latter, at about the middle of the central fissure, and that for the elbow and shoulder a little higher. Observation has shown that the centres for the upper extremity embrace the adjacent portions of the convolutions on both sides of the central fissure (Plate 10, Fig. 2). The movements of the hip, knee, leg, foot, and toes are presided over by the para-central convolution and the contiguous parts of the anterior and posterior central convolutions.

The inter-parietal fissure is probably the posterior limit of the motor area.

The frontal lobe of the brain anterior to the motor region seems to be related to the highest processes of the mind. Lesions in this locality are generally followed by proportionate mental deterioration.

The *sensorial area* has not been conclusively determined, but it is believed to include the general surface of the cerebrum posterior to the inter-parietal fissure, limited externally by the parieto-occipital fissure (Plate 7 and Plate 10, Fig. 2) and internally by the calloso-marginal fissure (Plate 8).

The centre for the movements of the eyes and eyelids involves the angular gyrus; while the centre for vision extends from the angular gyrus over the occipital lobe and adjoining portions of the temporal and parietal lobes. The centre for hearing seems to be localized in the first and second temporo-sphenoidal convolutions. The centre for smell is supposed to be established in the hook of the hippocampal convolution, and the centre for taste just below it. The speech-centre has already been mentioned in the description of the inferior frontal convolution (page 30). It is posterior to the fork of the fissure of Sylvius.

The function of the island of Reil, or central lobe, is not determined, but, from its development, its position, and its relation to the other lobes of the brain as well as the basal ganglia, it probably plays an important *rôle* in the association of their related functions.

During life the vessels of the pia mater are engorged with blood, especially if the patient has been under the influence of alcohol or an anæsthetic, and the subjacent cerebral fissures and sulci are indistinguishable through an opening in the skull. All that is possible, therefore, is to conjecture or infer what portion of the cortical surface of the brain is at the bottom of a hole made by the trephine (Plate 50, Fig. 1).

That the results of operative interference with the brain-structure should so often verify diagnosis is cause for wonder, when one considers the uncertain features of the anatomy of localization (Plates 9 and 10). Repeated examinations of the relations of the fissures to carefully mapped-out points after removal of a disk of bone on the heads of many cadavers have shown the author the fallacy of depending solely upon measurements, and the importance of making the artificial opening in the skull large enough to enable the operator to see the parts exposed.

The base of the cerebrum is subdivided, as already described, into anterior, middle, and posterior lobes for each hemisphere. The posterior lobes are separated from the cerebellum by the tentorium of the dura mater.

When the entire brain is removed from the calvarium and its *under surface* (Plate 6, Fig. 2) examined, the arrangement of the objects brought to view can be best studied by commencing in front. The *longitudinal fissure*, approximately in the middle line, separates the frontal lobes. Within the longitudinal fissure is the transverse commissure, or *corpus callosum*, from which white bands pass backward on each side to the fissure of Sylvius. They are called the *peduncles of the corpus callosum*. The *lamina cinerea* is a thin layer of gray tissue extending from the corpus callosum to the optic commissure. The fissure of Sylvius, between the frontal and middle lobes, lodges the middle cerebral artery, and the fissure begins in the *vallecula,* which is also known as the *anterior perforated space,* because it is perforated by the vessels which supply the corpus striatum. This anterior perforated space is the apparent origin of the three roots of the *first cranial nerves* (or *olfactory bulbs*) (Plate 6, Fig. 2), on each side. Each olfactory bulb is received into a straight furrow on the orbital surface of the frontal lobe and lies on the cribriform plate of the ethmoid bone (Plate 3, Fig. 1, No. 1). The outer white root of the olfactory bulb originates in a nucleus of gray matter in the anterior part of the middle lobe of the hemisphere, and from the fissure of Sylvius passes along the outer side of the anterior perforated space. The middle gray root takes origin from the anterior perforated space and the furrow in which it rests on the frontal lobe. The inner white root arises from the gyrus fornicatus on the median surface of the hemisphere. The olfactory bulbs are in reality the prolongations of the frontal portions of the cerebral substance. On their under surface, as they rest on the cribriform plate of the ethmoid bone, they give off about twenty nerves, which are distributed to the nasal mucous membrane (page 116). Behind the lamina cinerea is the *optic commissure,* formed by the union of the *optic tracts,* which arise from the anterior lobes (*nates*) of the corpora quadrigemina, the corpora geniculata, and the posterior portions of the optic thalami, winding round the crura cerebri.

In the skull the optic commissure rests upon the olivary process of the sphenoid bone, and from it the *second cranial nerves* (or *optic*), surrounded by prolongations of the dura mater, pass into the orbits through the optic foramina and enter the back of the eyeballs (Plate 5, Fig. 2, Nos. 8 and 21), eventually expanding into the retinæ. The ophthalmic arteries accompany the optic nerves through the optic foramina. The commissure consists of lateral fibres which pass from one optic tract to the optic nerve of the same side, anterior fibres which pass from one optic nerve to the other optic nerve, posterior fibres which pass from one optic tract to the other optic tract, and middle decussating fibres which cross from the optic nerve of one side to the optic tract of the other side.

The *tuber cinereum* is the gray prominence behind the optic commissure. This prominence is the floor of the third ventricle of the brain, and from it is projected a red-colored conical tube, the *infundibulum*, to which is attached the *pituitary body* (Plate 5, Fig. 3, No. 20). The pituitary body is lodged in the *sella turcica* of the sphenoid bone (Plate 12, No. 27), and is difficult to retain in removing the brain from the skull. It consists of two lobes, the posterior one being originally a prolongation downward of the cavity of the third ventricle through the infundibulum. Usually in later life the cavity in the posterior lobe of the pituitary body is obliterated. Behind the tuber cinereum are the *corpora albicantia* (Plate 6, Fig. 2, No. 34), which are formed by the bulbs of the fornix, the fibres of which pass downward, and then, after twisting in a figure-of-eight manner, pass upward to end in the optic thalami (Plate 8, Fig. 2, No. 11). Posterior to the corpora albicantia is a gray depression perforated by vessels which supply the optic thalami: it is called the *posterior perforated space*. It is placed between the diverging crura cerebri and in front of the pons Varolii. The *crura cerebri* consist of longitudinal fibres from the pons Varolii and upper part of the medulla oblongata, which pass forward and outward to the middle lobes of the hemispheres (Plate 6, Fig. 2). Division of one of the crura will exhibit in its middle some dark-colored tissue, called the *locus niger*, which separates the crus into two layers of fibres. The lower layer (the *crusta*) consists of coarse fibres arising from the anterior portion of the medulla and the pons. The upper layer (the *tegmentum*) is composed of fine fibres from the lateral portions of the medulla oblongata and also from the corresponding crus of the cerebellum. The lower fibres of each crus cerebri pass chiefly through the corpora striata, and the upper fibres through the optic thalami. In their passage through the ganglionic masses the fibres are greatly augmented, and, branching out, are distributed to the cortical substance on the surface of the hemispheres.

The *third cranial nerves* (or *oculo-motor*) appear just in front of the pons Varolii, issuing from among the fibres on the inner sides of the crura cerebri (Plate 6, Fig. 2, No. 11). These nerves originate from yellow nuclei beneath the passage-way between the third and fourth ventricles (*aqueduct of Sylvius*) (Plate 8, Fig. 1, No. 9), whence they pass forward through the locus niger and tegmentum in each of the crura, and, after passing through the plexus of veins called the cavernous sinus, in close relation to the internal carotid arteries, enter the orbits by means of the sphenoidal fissures, to be distributed to the muscles of the eye-balls, with the exception of the external recti and the superior oblique.

The *fourth cranial nerves* (or *trochlear*) (Plate 6, Fig. 2, No. 13) wind round the outer sides of the crura cerebri, having each originated from a gray nucleus in the floor of the aqueduct of Sylvius, very near the yellow nuclei of the third nerves. Their fibres decussate in the *roof* of the aqueduct, called the *valve of Vieussens*, about the middle line. They enter the orbit by the sphenoidal fissure and supply the superior oblique muscles (Plate 5, Fig. 2, No. 11).

The *fifth cranial nerves* (or *trifacial*) appear at the base of the brain, each issuing in two separate bundles of fibres from the sides of the pons Varolii near its anterior border (Plate 8, Fig. 2, Nos. 15 and 16). These nerves are the largest of the cranial nerves, and, owing to their complex character and important associations, are of the greatest interest. Each nerve has two distinct *roots*, and therefore resembles a spinal nerve; the anterior root is the smaller, consisting of three or four bundles of fibres, and having *motor* function, and the posterior the larger, composed of from seventy to one hundred bundles of fibres, and possessed of *sensory* function. The motor influences are chiefly confined to the muscles of mastication, while the sensory branches are distributed throughout the head and face (Plate 53, Fig. 1, No. 19). The two roots of this nerve commence in the upper portion of the medulla oblongata, the sensory root originating in the gray tubercle of Rolando, and the motor root from a nucleus of large cells closely connected with the posterior cornu of the medulla wherein the tubercle is situated. On its way forward the motor root receives some fibres from the floor of the fourth ventricle and also from the sides of the aqueduct of Sylvius.

As the two roots issue from the pons Varolii they are separated from each other by a few of the transverse fibres of this body. They proceed forward on the apex of the petrous portion of the temporal bone, where there is a depression (Plate 3, Fig. 5, No. 3) for a semilunar ganglionic enlargement which occurs here upon the sensory root. This is the *Gas-*

serian ganglion (Plate 5, Fig. 2, No. 25), and it furnishes additional resemblance to a spinal nerve, being somewhat similar to the ganglia on their posterior roots (Plate 4, Fig. 2). The motor root passes beneath the ganglion, and has no connection with it,—proceeding independently with the inferior maxillary branch of the sensory root through the foramen ovale, and after its exit at this foramen blending its fibres with those of that nerve. From the anterior border of the Gasserian ganglion three great nerve-trunks are given off,—viz., the *ophthalmic nerve,* which passes through the sphenoidal fissure with the third, fourth, and sixth nerves and the ophthalmic vein, the *superior maxillary nerve,* which passes through the foramen rotundum, and the *inferior maxillary nerve,* which passes through the foramen ovale, by which the lesser meningeal artery (Plate 3, Fig. 2) also enters the skull.

The *sixth cranial nerves* (or *abducent*) emerge between the pons and the anterior pyramids of the medulla oblongata (Plate 6, Fig. 2, No. 17), being connected with both of them. Their deep origins are in the fasciculi teretes in the floor of the fourth ventricle. They leave the skull by the sphenoidal fissures, passing between and supplying the two portions of the external recti muscles of the eyeballs (Plate 5, Fig. 2, No. 13).

The *seventh cranial nerves* (or *facial*) have their deep origins in the floor of the fourth ventricle, whence they pass more superficially than the sixth nerves, and, bending abruptly upon themselves, emerge between the pons and the restiform tract of the medulla oblongata. They enter the internal auditory openings in the temporal bones, and, after passing through the aqueduct of Fallopius (Plate 3, Fig. 5, No. 9) and giving off petrosal branches in their course, pass out by the stylo-mastoid foramina, to be distributed to the facial muscles.

The *eighth cranial nerves* (or *auditory*) also arise from the floor of the fourth ventricle, and are in close relation with the seventh nerves, a connecting link of nerve-tissue (the *pars intermedia* of Wrisberg) being interposed between both of them on each side. On account of this intimate relation, the facial and auditory nerves were formerly classified as two separate portions of the seventh cranial nerve, and because of their difference in character the former was called the *portio dura* and

PLATE 6.

Figure 1.

The upper surface of the brain of a white man about forty-five years of age, in sound condition and normal in general conformation, size, and weight. The right hemisphere is larger than the left, the longitudinal fissure not being in the middle of the cerebral mass. The pia mater has been removed to demonstrate the surface markings.

1. The longitudinal fissure.
2. The left frontal lobe.
3. The left fissure of Rolando.
4. The left parietal lobe.
5. The left calloso-marginal fissure.
6. The left supra-marginal convolution.
7. The left angular convolution (*gyrus*).
8. The left occipital lobe.
9. The right superior frontal convolution.
10. The right middle frontal convolution.
11. The right inferior frontal convolution.
12. The right ascending frontal convolution.
13. The right fissure of Rolando.
14. The right ascending parietal convolution.
15. The end of the horizontal branch of the right fissure of Sylvius.
16. The right parieto-occipital fissure.
17. The right inferior occipital convolution.
18. The right middle occipital convolution.
19. The right superior occipital convolution.

Figure 2.

The under surface of the same brain as in Figure 1, showing the superficial origins of the cranial nerves. The pia mater is removed from the cerebrum, although retained over the cerebellum.

1. The longitudinal fissure.
2. The right olfactory convolution.
3. The right orbital convolution.
4. The right frontal lobe.
5. The right olfactory bulb (or first cranial nerve).
6. The right fissure of Sylvius.
7. The lamina cinerea.
8. The right optic nerve (or second cranial nerve).
9. The right temporo-sphenoidal lobe.
10. The right middle temporo-sphenoidal convolution.
11. The right oculo-motor nerve (or third cranial nerve).
12. The right inferior temporo-sphenoidal convolution.
13. The right trochlear nerve (or fourth cranial nerve).
14. The lobulus fusiformis.
15. The motor root of the right trifacial nerve (or fifth cranial nerve).
16. The sensory root of the trifacial nerve.
17. The right abducent nerve (or sixth cranial nerve).
18. The right facial nerve (or seventh cranial nerve).
19. The right auditory nerve (or eighth cranial nerve).
20. The right glosso-pharyngeal nerve (or ninth cranial nerve).
21. The right pneumogastric nerve (or tenth cranial nerve.)
22. The right hypoglossal nerve (or twelfth cranial nerve).
23. The right spinal accessory nerve (or eleventh cranial nerve).
24. The gray substance of the medulla oblongata.
25. The right lobe of the cerebellum.
26. The left first frontal convolution (*gyrus rectus*).
27. The left middle frontal convolution.
28. The left third frontal convolution.
29. The left olfactory bulb (or first cranial nerve).
30. The left fissure of Sylvius.
31. The anterior perforated space.
32. The optic commissure.
33. The pituitary body.
34. The corpora albicantia.
35. The left oculo-motor nerve (or third cranial nerve).
36. The posterior perforated space.
37. The left trochlear nerve (or fourth cranial nerve).
38. The left trifacial nerve (or fifth cranial nerve).
39. The pons Varolii.
40. The left abducent nerve (or sixth cranial nerve).
41. The left facial nerve (or seventh cranial nerve).
42. The left auditory nerve (or eighth cranial nerve).
43. The left glosso-pharyngeal nerve (or ninth cranial nerve).
44. The left pneumogastric nerve (or tenth cranial nerve).
45. The left olivary body.
46. The left hypoglossal nerve (or twelfth cranial nerve).
47. The left spinal accessory nerve (or eleventh cranial nerve).
48. The left occipital lobe of the cerebrum.
49. The left lobe of the cerebellum.

Fig 1

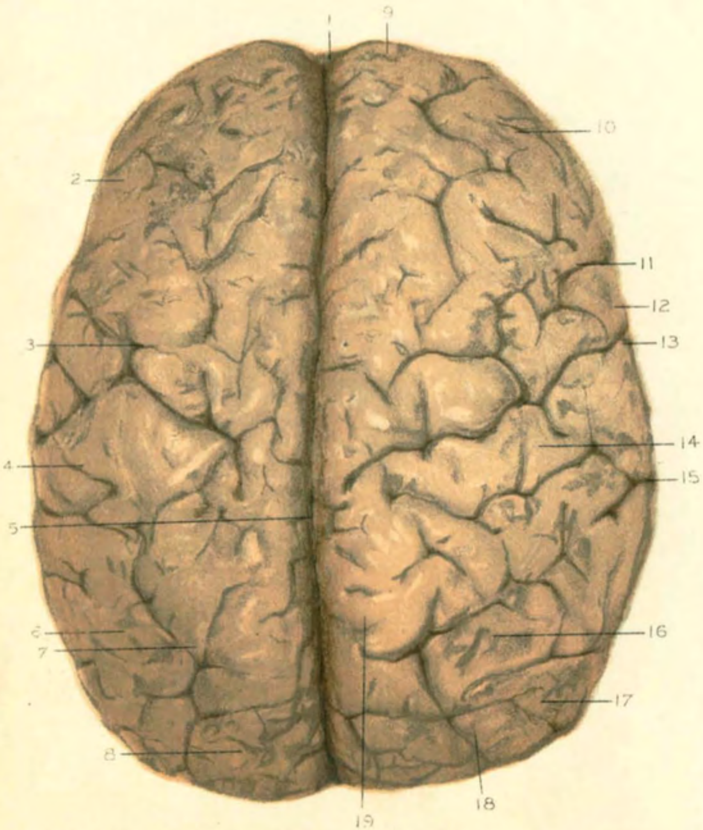
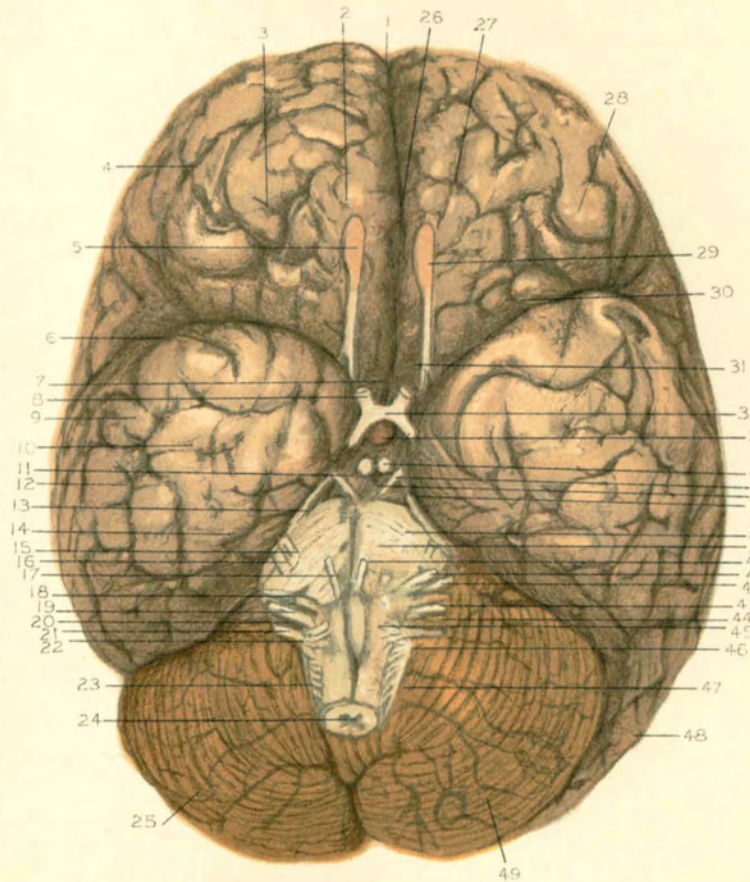


Fig 2



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the latter the *portio mollis.* The auditory nerves commence by fibres which originate in the outer and inner auditory nuclei beneath the acoustic tubercles on each side of the floor of the fourth ventricle, and, after receiving some fibres from the transverse striæ in this situation, unite into individual trunks which enter the internal auditory openings of the temporal bones in company with the facial nerves. Within the auditory openings these nerves subdivide into cochlear and vestibular branches, which are distributed to the internal ears (page 78).

The *ninth cranial nerves* (or *glosso-pharyngeal*) appear on the surface of the restiform bodies, below the auditory nerves (Plate 6, Fig. 2, No. 20). The deep origins of these nerves are very close to those of the auditory nerves in the floor of the fourth ventricle. They make their exits from the cranium by means of the middle compartments of the jugular foramina, and are distributed to the mucous membrane of the pharynx and back of the tongue (Plate 13, Fig. 2, No. 16).

The *tenth cranial nerves* (or *pneumogastric*) also appear on the restiform bodies, in close proximity to the preceding nerves (Plate 6, Fig. 2, No. 21). Their fibres of origin arise from special nuclei in the inferior part of the fourth ventricle, and soon blend together, forming single nerve-trunks which pass through the jugular foramina and are distributed to the pharynx, larynx, heart, lungs, œsophagus, and stomach (Plate 36, No. 61, and Plate 37, No. 32). The pneumogastric nerve is of extreme interest and importance, and is often called the *vagus nerve,* from its wandering course.

The *eleventh cranial nerves* (or *spinal accessory*) are each composed of two separate parts, an upper or accessory part, which arises from the medulla below the pneumogastric, and a lower part, which arises from the spinal cord (Plate 6, Fig. 2, No. 23). The deep origin of the upper part commences in a special nucleus about the *calamus scriptorius* in the fourth ventricle. The spinal part of this nerve is composed of fibres which originate as low down on the cord as the fifth cervical vertebra, and it enters the skull at the foramen magnum to join the accessory part. The combined nerve then passes out of the jugular foramen with the pneumogastric and glosso-pharyngeal nerves, the accessory portion blending with the pneumogastric, while the spinal portion (Plate 13, Fig. 1, No. 8, and Plate 21, No. 13) supplies the sterno-mastoid and trapezius muscles.

The *twelfth cranial nerves* (or *hypoglossal*) appear on the surface of the medulla oblongata, in the grooves between the olivary bodies and the anterior pyramids (Plate 6, Fig. 2, No. 46). The special nuclei from which the fibres of these nerves originate are to be found on the floor of the fourth ventricle in front of and nearer the middle line than the nuclei for the pneumogastric nerves. The fibres are formed into two bundles which pierce the dura mater through separate openings and afterward combine within the anterior condyloid foramina, their final distribution being to the muscles of the tongue (Plate 13, Fig. 2, No. 19) and the depressor muscles of the hyoid bone and larynx.

It will be noticed that most of the cranial nerves originate in the neighborhood of the fourth ventricle (or ventricle of the cerebellum) and the top of the medulla oblongata. These portions of the brain are therefore of the greatest importance. The pons Varolii and the medulla oblongata, which rest upon the basilar portions of the occipital and sphenoid bones, have in the natural state interposed between them and the bone, as well as between them and the superposed cerebrum and cerebellum, a quantity of cerebro-spinal fluid which collects in the *anterior* and *posterior sub-arachnoidean spaces.* This fluid serves to equalize pressure and affords resistance to shock, especially from the effects of injury by *contre-coup.* The sub-arachnoid space communicates with the ventricular cavities of the brain by the foramen of Magendie, which is an aperture in the pia mater closing in the fourth ventricle. The aqueduct of Sylvius connects the fourth ventricle with the third ventricle at the base of the brain, and the latter is connected in front with the lateral ventricles by the foramen of Monro.

The *medulla oblongata* (Plate 6, Fig. 9, No. 24) is the upper expanded extremity of the spinal cord on a level with the lower border of the foramen magnum. It is a white, pyramidal body, two and one-half centimetres, or about an inch, in length, and is partially divided anteriorly and posteriorly by median fissures. The *anterior median fissure* ends in the *foramen cæcum* just below the pons Varolii. The *posterior median fissure* expands into the floor of the fourth ventricle. Each half of the medulla oblongata consists of four longitudinal masses,—viz., the *anterior pyramids,* the *lateral tracts* and *olivary bodies,* the *restiform bodies,* and the *posterior pyramids.* The *anterior pyramids* increase in breadth as they approach the pons Varolii, through which their fibres pass to reach the crura cerebri. They are continuous with the anterior columns of the spinal cord, and consist of *motor* fibres. When the anterior pyramids are separated at their commencement, their inner nerve-fibres, below the surface, are readily seen decussating at the bottom of the anterior fissure. The outer fibres do not decussate, and ascend directly upward. An injury received upon one side of the brain is followed by loss of motion on the opposite side of the body (*cross-paralysis*), which effect is explained by the decussation of the inner fibres of the medulla which are continuous with the fibres of the lateral tracts of the opposite sides.

The *lateral tracts* are situated on the outer side of the anterior pyramids. The *olivary bodies* project from the upper part of the lateral tracts, being separated by a depression from the pons. They are embraced by the ascending fibres of the lateral tracts as they diverge on their way to the pons and restiform bodies. These ascending fibres from the lateral tracts are more or less obscured by the *arciform fibres,* which loop across the surface and connect the anterior pyramids with the restiform bodies. The roots of the hypoglossal, glosso-pharyngeal, pneumogastric, and spinal accessory nerves emerge from the medulla in the immediate vicinity of the olivary bodies. The *olivary nucleus* is a layer of gray tissue within the olivary body upon each side, which presents on section a jagged toothed appearance, in consequence of which it is also called the *corpus dentatum.* The *restiform bodies* are the continuation upward of the posterior columns of the spinal cord. They diverge toward the cerebellum, constituting its inferior peduncles, and with the posterior pyramids assist in forming the lateral boundaries of the fourth ventricle. Gray matter is found in the interior of the restiform bodies.

The *posterior pyramids* (*funiculi graciles*) are the two slender bundles on each side of the posterior median fissure, which diverge at the apex of the fourth ventricle. The enlargement upon each of the posterior pyramids at this locality is called the *clava*, and it contains within it some gray matter, the *nucleus gracilis*. From the clava the posterior pyramid on each side gradually dwindles, its fibres passing to the cerebrum along the floor of the fourth ventricle and constituting with the fibres from the adjacent restiform body, which take the same course, the *fasciculi teretes*. The *transverse striæ* on the floor of the fourth ventricle, which form the roots of the auditory nerves, are derived from the arciform fibres above described. They are chiefly composed of the fibres which do not enter the olivary body, but wind round beneath it and over the restiform body. The decussation of the fibres of the lateral tracts and the divergence of the restiform bodies and posterior pyramids cause a change in the arrangement of the gray matter in the upper part of the medulla oblongata, from the characteristic disposition of the gray matter in the spinal cord. The anterior cornua of the cord become separated from the mass of gray matter, owing to the decussation of the fibres from the lateral tracts, and behind the olivary bodies form the *lateral nuclei*. The rest of the gray matter of the anterior cornua in this locality is broken up into an interlacement of fibres, the *formatio reticularis*, by the longitudinal fibres from the lateral tracts being intersected by the deeper set of arciform fibres.

The pons Varolii (Plate 6, Fig. 2, No. 39) is situated just above the medulla oblongata, and in the skull rests upon the body of the sphenoid bone. It serves to connect the fibres of the medulla below with the cerebellum behind it by means of the crura cerebelli, as well as with the cerebrum above by means of the crura cerebri. The pons is defined above and below by very prominent margins, the upper margin arching over the crura cerebri, and the lower one, much less curved, distinguishing it from the medulla. A shallow groove in the middle of its anterior surface accommodates the basilar artery (Plate 11, Fig. 1, No. 15). A section of the pons will show that the anterior portion is mainly composed of white transverse fibres crossed by white longitudinal fibres. The longitudinal fibres ascend from the medulla to pass to the cerebrum, and occasion the prominences on each side of the anterior surface of the pons. The transverse fibres connect the hemispheres of the cerebellum. These fibres are arranged in layers having gray matter variously disposed among them, especially in the locality of the fourth ventricle, where most of the cranial nerves have their origin.

The cerebellum in the skull (Plate 5, Fig. 2, Nos. 14 and 27) occupies the inferior occipital fossæ, being protected by the tentorium of the dura mater from the weight of the overlying posterior lobes of the cerebrum. It consists of two lateral lobes or hemispheres separated posteriorly by the falx cerebelli of the dura mater and joined anteriorly by the *vermiform process,* or *central lobe.*

The cortical surface, which is darker than that of the cerebrum, is arranged in parallel curved folds, with intervening fissures which vary in depth from the centre and subdivide the surface into lobules. There are four lobules on each hemisphere, the *marginal lobule,* the *lobulus gracilis,* the *cuneiform* or *digastric lobule,* and the *amygdala* or *tonsil lobule.* The *horizontal fissure* separates the upper and lower surfaces of each hemisphere of the cerebellum. The space between the two hemispheres below is called the *valley.* The upper surface consists of the expanded middle lobe, which is here designated the *superior vermis.* In front there is a *notch* into which the optic lobes are received, the surface overlapping the superior peduncles of the cerebellum and the valve of Vieussens. Behind them is another notch, into which the internal occipital protuberance projects. The *superior vermis* is subdivided into four parts. The *central lobule* stands out prominently in front; beneath this and over the valve of Vieussens is the *lingula,* a flattened transverse lamella, with small ridges extending into it from the crura cerebelli, the *frœnula.* Behind the central lobule is the *monticulus cerebelli,* and posteriorly is the smaller portion called the *commissura simplex.*

The lamellæ constituting the monticulus continue into the *quadrilateral lobules* on each side, and those which form the commissura pass to the *posterior* or *crescentic lobules.* The *inferior vermis* can best be seen after removing the *amygdalæ.* It consists of three portions,—the *pyramid,* the *uvula,* and the *nodulus.* At the anterior part of the under surface is the *sub-peduncular lobule,* or *flocculus.* Passing from the nodulus to the floc-

PLATE 7.

Figure 1.

The convolutions and fissures on the external surface of the right hemisphere. (Of same brain as in Plate 6.)

1. The fissure of Rolando.
2. The ascending parietal convolution.
3. The superior parietal convolution.
4. The calloso-marginal fissure.
5. The inter-parietal fissure.
6. The inferior parietal convolution.
7. The angular convolution.
8. The occipito-parietal fissure.
9. The superior occipital convolution.
10. The middle occipital convolution.
11. The inferior occipital convolution.
12. The transverse fissure (of Bichat).
13. The right lobe of the cerebellum.
14. The ascending frontal convolution.
15. The superior frontal convolution.
16. The posterior frontal fissure.
17. The middle frontal convolution.
18. The horizontal branch of the fissure of Sylvius.
19. The inferior frontal convolution.
20. The ascending branch of the fissure of Sylvius.
21. The superior temporal convolution.
22. The fissure of Sylvius.
23. The middle temporal convolution.
24. The inferior temporal convolution.
25. The pons Varolii.
26. The medulla oblongata.

Figure 2.

The convolutions and fissures on the external surface of the left hemisphere. (Of same brain as in Plate 6.)

1. The fissure of Rolando.
2. The ascending frontal convolution.
3. The superior frontal convolution.
4. The posterior frontal fissure.
5. The middle frontal convolution.
6. The horizontal branch of the fissure of Sylvius.
7. The central lobe, seen on this side externally, in the fork of the fissure of Sylvius.
8. The ascending branch of the fissure of Sylvius.
9. The inferior frontal convolution.
10. The superior temporal convolution.
11. The middle temporal convolution.
12. The fissure of Sylvius.
13. The optic nerve.
14. The inferior temporal convolution.
15. The pons Varolii.
16. The medulla oblongata.
17. The calloso-marginal fissure.
18. The ascending parietal convolution.
19. Annectant convolutions.
20. The inter-parietal fissure.
21. The occipito-parietal fissure.
22. The angular convolution.
23. The superior occipital convolution.
24. The middle occipital convolution.
25. The inferior occipital convolution.
26. The transverse fissure.
27. The left lobe of the cerebellum.

Fig 1

Fig 2

Dissected, Photographed and Colored from Nature by George Mc Clellan, M.D.

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culus is a thin valve-like fold of white matter, which is called the *posterior medullary velum.* This velum as it passes from the cerebellum becomes a very delicate layer of tissue covered with pia mater, and closes in the fourth ventricle. A longitudinal section of one of the hemispheres (Plate 11, Fig. 3, and Plate 12) will disclose a mass of white substance with radiating branches upon which the gray cortical substance is infolded. This is the *arbor vitæ* of the cerebellum (Plate 8, Fig. 1, No. 12). The white substance of each hemisphere contains in its centre a nucleus of gray matter, the *corpus dentatum.*

The function of the cerebellum has been concluded from physiological observations to be the co-ordination of muscular movements. As above described, the cerebellum is connected with the medulla oblongata by the fibres which ascend from the restiform tracts and constitute the *inferior peduncles,* or *inferior crura.* The lateral parts of the pons Varolii are the *middle peduncles,* or *middle crura,* of the cerebellum; and its *superior peduncles,* or *superior crura,* are the fibres which connect it with the cerebrum. The innermost fibres of the superior peduncles decussate beneath the corpora quadrigemina, so that some fibres from one half of the cerebrum are continued into the opposite half of the cerebellum. Many of these fibres have been traced into the corpora dentata. Each of the superior peduncles (*processus e cerebello ad testes*) forms the upper part of the lateral boundary of the fourth ventricle, and is connected with its opposite fellow by means of the *valve of Vieussens,* or *superior medullary velum.* The valve is a thin layer of gray matter which forms the upper wall or roof of the important fourth ventricle (Plate 8, Fig. 2, No. 25).

The *fourth ventricle* is the space between the cerebellum and the posterior surfaces of the medulla oblongata and the pons Varolii. Upon vertical section (Plate 8, Fig. 1, No. 10) it appears triangular in shape. This subdivision of the general ventricular cavity is the first part of the primordial central canal formed in the fœtus. As just stated, the fourth ventricle is roofed over by the valve of Vieussens, bounded on each side by the superior peduncles of the cerebellum, and behind by the diverging posterior pyramids and restiform bodies.

Inferiorly the arachnoid membrane is continued on to the posterior surface of the spinal cord, an aperture usually existing here, called the *foramen of Magendie,* by which the ventricle communicates with the subarachnoidean space. A median furrow exists in the floor of this ventricle, which begins below in a pit (the ventricle of Arantius) and ends in the aqueduct of Sylvius. The divergence of the inferior cerebellar peduncles from this median furrow constitutes a resemblance to the point of a quill pen, and forms the *calamus scriptorius* of the old anatomists. The *obex* is an arching fold of tissue hanging over the apex of the calamus scriptorius. On each side of the median furrow are longitudinal eminences, the *fasciculi teretes,* which are crossed by the *transverse striæ* (or *striæ acousticæ*) toward the posterior part of the ventricle. Externally to the fasciculus teres on each side is a shallow groove which terminates below in a depression, the *fovea posterior*, within which is the *cinereous eminence.* The *fovea anterior* is another depression in this groove, opposite the widest part of the ventricle. The *auditory eminences* are on each side between the foveæ. These are crossed by the above-mentioned *striæ acousticæ.* The *locus cæruleus* is the name given to a variable bluish-gray nucleus in the upper angle of the ventricle. Besides these objects on the floor of the fourth ventricle there are the nuclei of the cranial nerves which originate here. The pia mater (*velum interpositum*), lining the fourth ventricle, is continued into the third ventricle by the aqueduct of Sylvius (or *iter a tertio ad quartum ventriculum*). The aqueduct is about half an inch long, and contains in its walls a large amount of gray matter, in which are the nuclei for the third, fourth, and upper part of the fifth cranial nerves. In front of and above the aqueduct of Sylvius are two pairs of bodies,—the *corpora quadrigemina* (Plate 8, Fig. 2, No. 24), or more properly the *optic lobes,* as they give origin to the optic nerves. They are relatively smaller in man, although their size in most animals bears relation to the power of sight. In birds there is only one pair of optic lobes; in the early stage of the human embryo there is only one pair also, but about the seventh month of fœtal life this pair is subdivided into two by a transverse groove. The posterior pair are the smallest, and are called the *testes;* the anterior pair, the *nates,* are larger and of a darker color. Immediately in front of the nates is situated a very vascular cone-shaped body,—the *conarium*, or *pineal gland.* It is about the size of a cherry-stone, and consists of many small follicles containing cells. These cells have a gritty substance within them (*acervulus cerebri*) consisting of carbonate of calcium and phosphate of calcium and of magnesium. This curious little body is larger in the child and in the adult female than in the adult male. Its function is unknown, but in birds is supposed to be associated with their homing instinct. The pineal gland is connected with the cerebrum by two white bands or crura (the *peduncles of the pineal gland*) which extend forward upon the inner sides of the optic thalami in the lateral walls of the third ventricle.

The *third ventricle* is the narrow oblong fissure into which the aqueduct of Sylvius, which passes beneath the corpora quadrigemina, opens anteriorly. Its floor is formed by the parts within the inter-peduncular space at the base of the brain,—viz., the posterior perforated space, the corpora albicantia, the tuber cinereum, the infundibulum, and the lamina cinerea (Plates 6 and 8). The velum interpositum is stretched across above, and with the *fornix*, the arching layer of white matter beneath the corpus callosum, forms the roof of the third ventricle.

The cavity of this ventricle is crossed by *three* commissural bands. The *posterior commissure* is just in front of the pineal gland, and is composed of white fibres which serve to connect the optic thalami. The *middle* or *soft commissure* is about half an inch broad, composed of gray matter, and also serves to connect the optic thalami. It is not always found even upon careful examination. The *anterior commissure* is a round white cord in the fore part of the cavity of the ventricle, the fibres of which pass through the adjacent corpora striata and extend into the temporo-sphenoidal lobes of the cerebrum. Just behind the anterior commissure is the *foramen of Monro*, an aperture leading into a short passage which soon branches after the manner of the letter Y, thus affording a communication between the third ventricle and the two lateral ventricles, by which the choroid plexuses of opposite sides are joined. The *velum interpositum* is a duplicature of the pia mater which is projected into the ventricular cavity of the cerebrum through the breach between its posterior lobes and the cerebellum (the transverse fissure of Bichat, Plate 8, Fig.

2, No. 22). Its shape corresponds to that of the fornix, its projecting borders being the convoluted fringes called the *choroid plexuses* (Plate 11, Fig. 2, Nos. 8 and 19). These plexuses consist of minute arteries and veins in connective tissue. In the centre of the velum are two large veins (the *venæ Galeni*) which convey the blood from the great cerebral ganglia into the straight sinus (Plate 4, Fig. 1, No. 9).

The ganglionic masses at the base of the brain consist of two pairs. The anterior are called, from their internal arrangement of alternate white and gray layers, the *corpora striata*. The posterior are the *optic thalami*, which are oval, elevated masses placed on each side of the third ventricle, and, embracing the crura cerebri, project portions of their upper surfaces in the floors of the lateral ventricles. They are exposed by removing the choroid plexuses. They are composed of gray substance covered with a superficial thin layer of white tissue. The upper surface of each thalamus is subdivided by an oblique groove into an *anterior tubercle* and a *posterior tubercle*, or *pulvinar*. Beneath and behind the optic thalami on each side are two small gray eminences, known as the *corpora geniculata, internum* and *externum* according to their position. They are in relation to the roots of the optic tract (the *brachia*), and are connected posteriorly by white bands with the corresponding corpora quadrigemina.

The inner margins of the optic thalami are covered by the choroid plexuses, which separate them from the *fornix*, which is the layer of white matter arching over the inter-thalamic region and enclosing the third ventricle.

The *fornix* consists of a triangular central portion, the *body*, the broadest part of which is posterior to and closely connected with the corpus callosum, and anterior and posterior prolongations, known as the *pillars* or *crura of the fornix*. The *posterior pillars* descend from the outer angles of the body into the middle cornua of the lateral ventricles, constituting the *hippocampi majores* and terminating in the *pes hippocampi*. In their course they are in contact with the pulvinar of the optic thalamus on each side. The *anterior pillars* curve downward from the front of the body of the fornix, leaving the corpus callosum about the position of the foramen of Monro in the floor of the third ventricle, and, receiving the peduncles of the pineal gland and fibres from the tænia and septum lucidum, pass to the base of the brain, their component fibres twisting in a figure-of-eight manner and returning upward and backward into the fore portions of the optic thalami. The curve which the fibres of each anterior pillar take at the base of the brain forms the *corpus albicans* of that side, as has been previously stated in the view of that region.

On the portion of the under surface of the fornix which rests on the velum interpositum there are some transverse fibres which pass from the corpus callosum and form the *lyra.*

The *septum lucidum* (Plate 8, Fig. 2, No. 6) is a delicate, almost translucent, vertical partition extending from the front of the fornix, where it bends downward, and attached above and below to the under surface of the corpus callosum. It consists of two layers, gray on the inside and white without, and the space between them is called the *fifth ventricle.* This septum serves to divide the upper ventricular space within the hemispheres of the cerebrum into the *right* and *left lateral ventricles.* In cases of serous effusion within the general ventricular cavity of the brain the septum is often ruptured and free communication exists from side to side.

The *lateral ventricles* (Plate 11) are semilunar in shape, and consist of a central part, or *body*, and *anterior*, *middle*, and *posterior cornua*, which extend respectively into the frontal, temporo-sphenoidal, and occipital lobes. The floor of the central portion of either of the lateral ventricles presents many objects of interest, which have the following relative positions. Posteriorly the margin of the posterior pillar of the fornix (the *corpus fimbriatum*) appears as a white cord accompanying the hippocampus major and sometimes called on this account the *tænia hippocampi.* In front of this is the choroid plexus, which usually extends so far forward into the cavity that very little of the subjacent optic thalamus is seen unless it is purposely uncovered. Beyond the thalamus, and separating it from the caudate portion of the corpus striatum, or anterior ganglionic mass, is the white band called from its course the *tænia semicircularis.* The tænia descends anteriorly in connection with the anterior pillar of the fornix, and blends with the fibres composing the corpus albicans, as previously described. Posteriorly it passes into the middle cornu of the lateral ventricle, apparently losing itself in the white substance in that cavity, but eventually terminating in the gray mass, the *nucleus amygdalæ.* Owing to the upper surface of the tænia being somewhat harder than its deeper part, it was called by Tarinus the *horny band.*

In the fore part of the centre of the lateral ventricle is seen the *intra-ventricular portion* of the *corpus striatum* (Plate 11, Fig. 2, No. 15). This ganglionic centre is best understood by making a horizontal section through it from the tænia semicircularis outward, where it appears to consist of five parts. The intra-ventricular portion, or the *caudate nucleus,* of the corpus striatum, above mentioned, is a gray, pear-shaped mass, the broad part of which is directed forward into the lateral ventricle, and its narrow end, the *tail* or *surcingle,* is continued into the middle cornu as far as the nucleus amygdalæ. The surface of the caudate nucleus in the recent state is covered with a plexus of veins which empty into the venæ Galeni. The *extra-ventricular portion* or *lenticular nucleus* (Plate 11, Fig. 1, No. 6) of the corpus striatum is the largest, and is lodged within the white substance of the hemisphere, being separated from the caudate nucleus by a layer of white matter, the *internal capsule* (Plate 11, Fig. 1, No. 12).

On the external surface of the lenticular nucleus is another layer of white tissue, the *external capsule* (Plate 11, Fig. 1, No. 30), which again separates this portion from a thin layer of gray matter, the *claustrum.* External to the latter is the white matter which is subjacent to the central lobe, or island of Reil, the claustrum being formed by a portion of the under surface of the convolutions of the latter turned inward.

A vertical transverse section of the lenticular nucleus demonstrates that it is composed of three smaller nuclei, the inner one gray, the middle dark yellow, and the outer of a reddish color. These parts are separated by layers of fibres which originate in the convolutions of the operculum. The *nucleus amygdalæ* underlies the corpus striatum, and is in relation with the tail of the caudate nucleus, being continuous with the deep-seated cortex of the temporal lobe. The caudate and lenticular nuclei are united by many gray striæ, which cross the internal capsule and give to the mass the peculiar striation to which it owes its name.

The *internal capsule* consists of white fibres passing between the caudate nucleus and the thalamus opticus and the lenticular nucleus. Its anterior portion, or *caudo-lenticular limb*, is composed of fibres from the frontal lobe, and its posterior portion, or *thalamo-lenticular limb*, consists of motor fibres from the operculum on their way through the crusta of the crus cerebri to the anterior pyramid of the medulla oblongata. Fibres from the temporal and occipital lobes also compose the extreme end of the *thalamo-lenticular limb*, passing through the crus cerebri and pons to the cerebellum. There are also fibres passing from the cortex to the thalamus and to the gray matter in the pons. These fibres diverge above the caudate nucleus and intermingle with the fibres of the corpus callosum. The *external capsule* is thinner than the *internal*, with which it is continuous behind. It consists of white fibres in connection with the claustrum derived from the crus cerebri and the anterior commissure of the third ventricle.

The *posterior cornua* (or digital cavities) of the lateral ventricles are not always equally developed in both hemispheres, and they are sometimes absent. They usually curve backward into the substance of the occipital lobes. In the floor of each posterior cornu is a claw-shaped eminence, the *hippocampus minor*, which is also known as the *calcar*, because it is produced by the infolding of the contiguous convolutions of the calcarine fissure. Between the posterior and middle cornua there is a smooth mass of variable size, the *eminentia collateralis* (or the *pes accessorius*), formed by the inward protrusion of the collateral fissure. The *middle* or *descending cornua* are the largest of the prolongations of the cavity of the lateral ventricles. They pass downward into the temporo-sphenoidal lobes toward the base of the brain, making remarkable curves backward, outward, and downward round the backs of the optic thalami, and forward and inward round the crura cerebri, resembling somewhat the horns of a ram, and hence are also known as the *cornua Ammonis*. They terminate in close proximity to the fissures of Sylvius. Continuous with the hippocampus minor, from the posterior cornu on each side, is a long, white, rounded eminence which follows the curve of the middle cornu and occupies the principal part of its cavity, the

PLATE 8.

Figure 1.

The convolutions and fissures of the inner surface of the left hemisphere of the cerebrum, and median section through the base of the brain, cerebellum, pons Varolii, and medulla oblongata. (From same brain as in Plates 6 and 7.)

1. The ascending frontal convolution.
2. The fissure of Rolando.
3. The ascending parietal convolution.
4. The præcuneus, or quadrate lobe.
5. The parieto-occipital fissure.
6. The cuneus, or cuneate lobe.
7. The calcarine fissure.
8. The corpora quadrigemina.
9. The aqueduct of Sylvius, leading from the third to the fourth ventricle.
10. The fourth ventricle.
11. The transverse fissure.
12. The arbor vitæ of the cerebellum.
13. The left lobe of the cerebellum.
14. The superior frontal convolution.
15. The calloso-marginal fissure.
16. The fornicate convolution.
17. The corpus callosum.
18. The anterior bend of the calloso-marginal fissure.
19. The septum lucidum.
20. The fornix.
21. The thalamus opticus.
22. The inferior frontal convolution.
23. The corpus albicans.
24. The optic nerve.
25. The fissure of Sylvius.
26. The motor oculi nerve.
27. The pons Varolii.
28. The temporo-sphenoidal lobe.
29. The medulla oblongata.

Figure 2.

The convolutions and fissures of the inner surface of the right hemisphere of the cerebrum, and median section through the base of the brain, cerebellum, pons Varolii, and medulla oblongata. (From same brain as in Plates 6 and 7.)

1. The superior frontal convolution.
2. The calloso-marginal fissure.
3. The middle frontal convolution.
4. The fornicate convolution.
5. The corpus callosum.
6. The septum lucidum.
7. The fornix.
8. The anterior pillar of the fornix.
9. The optic thalamus.
10. The inferior frontal convolution.
11. The corpus albicans.
12. The optic nerve.
13. The motor oculi nerve.
14. The pons Varolii.
15. The medulla oblongata.
16. The fissure of Rolando.
17. The calloso-marginal fissure.
18. The quadrate lobe.
19. The corpus callosum.
20. The parieto-occipital fissure.
21. The cuneate lobe.
22. The velum interpositum.
23. The calcarine fissure.
24. The corpora quadrigemina.
25. The valve of Vieussens.
26. The great transverse fissure.
27. The fourth ventricle.
28. The arbor vitæ of the cerebellum.
29. The right lobe of the cerebellum.

Plate

Fig 1

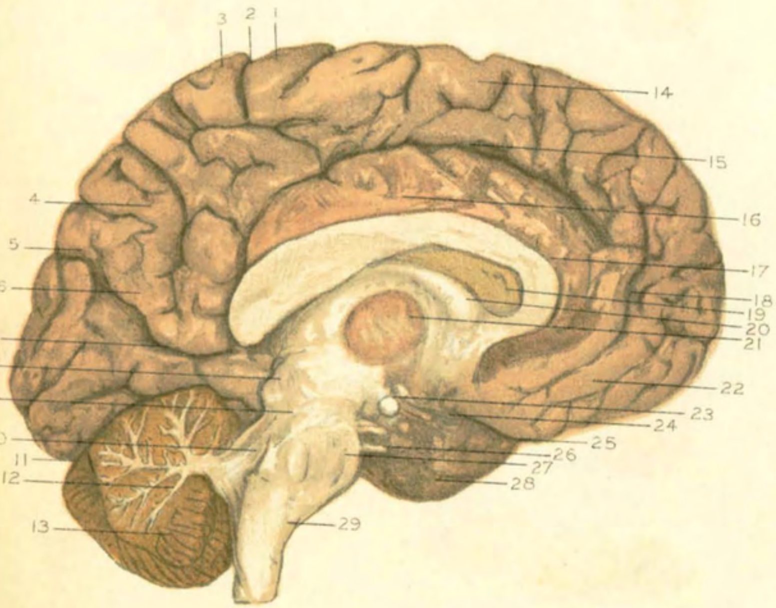
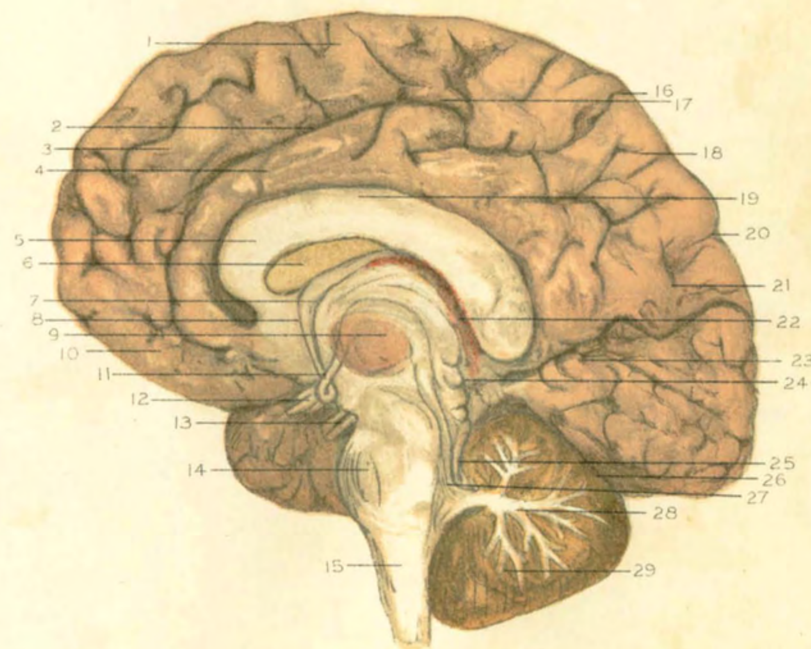


Fig 2



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hippocampus major. This body is formed by the reduplication of the hippocampal convolution. Extending along its upper margin is the *tænia hippocampi,* or white band continuous with the posterior pillar of the fornix, as previously described. At the lower extremity of the hippocampus major there are four or five small elevations with intervening depressions, producing a fancied likeness to the paw of an animal, and hence called the *pes hippocampi.* Along the inner border of the hippocampus major about the hippocampal fissure (which is really the lateral part of the transverse fissure) there is an edge composed of white fibres from the fornix (*corpus fimbriatum*) passing to the uncinate gyrus. Here there is a notched ridge of gray matter, the *fascia dentata,* which derives its name from the arrangement of the choroid arteries as they pass through the *dentate fissure* into the middle cornu. The *anterior cornua* of the lateral ventricles curve outward from each other into the substance of the frontal lobes round the caudate nucleus of the corpus striatum.

The general roof of the lateral ventricles is formed by the *corpus callosum,* which, owing to its being formed of white transverse fibres extending between the hemispheres, is called the *great transverse commissure* of the cerebrum. The *corpus callosum* (Plate 8, Fig. 2, No. 5) is thicker and broader at its back part, the *splenium,* which is in relation with the transverse fissure where the pia mater enters the ventricles. It arches forward over the ventricular cavity, ten centimetres, or about four inches, in length, and anteriorly bends downward and backward, forming the *genu.* The lowest part of the bend is called the *rostrum* (or beak), and terminates in the two *peduncles of the corpus callosum,* they severally disappearing in the fissures of Sylvius. Upon the upper surface of the corpus callosum there is a middle groove, or *raphé,* and, in the recent state, on each side of this groove are readily distinguished two white *longitudinal striæ,* called the *nerves of Lancisi.* Parallel and external to these are other fibres, the *lateral striæ.* The anterior cerebral arteries proceed from before backward on the upper surface, and are here called the arteries of the corpus callosum (Plate 4, Fig. 1, No. 16). On its external borders the corpus callosum is overlapped on each side by the *gyri fornicati* (Plate 8). The borders themselves are known as the *labia* *cerebri*, and the spaces between them and the commissure are the *ventricles of the corpus callosum*. If a section through the brain is made, either vertically or horizontally, the white matter is spotted with dots (the *puncta vasculosa*), due to the escape of blood from the severed vessels of the medullary substance (Plate 11, Fig. 2, No. 13).

The medullary substance of the cerebrum consists of fine white fibres, which may be described as longitudinal, transverse, and diverging fibres. The *longitudinal fibres* compose the fornix, the striæ longitudinales, the tæniæ semicirculares, the gyri fornicati, the gyri uncinati, and the peduncles of the pineal gland. The *transverse fibres* connect the two hemispheres, and are found in the corpus callosum and the anterior and posterior commissures. The *diverging* (or *peduncular*) *fibres* are derived partly from the crusta and partly from the tegmenta of the crura cerebri, having originated in the cord and medulla oblongata. Those from the crusta are derived mainly from the anterior pyramids of the medulla, receiving *en route* through the crusta fibres from the gray walls of the aqueduct of Sylvius and the locus niger, and pass forward and outward to the internal capsule between the caudate and lenticular nuclei on each side. They distribute fibres to the nuclei of the corpora striata and receive others from them, and after issuing from the capsule radiate in all directions toward the cortical surface of the cerebrum, forming the *corona radiata*. Many of the fibres of the crusta have been traced directly through the internal capsule to the cortex. The so-called *pyramidal tract* is composed of such fibres passing to the gray surface-matter of the ascending frontal and parietal convolutions in the neighborhood of the fissure of Rolando. Some bundles of the fibres on the outer portion of the crusta have been traced into the occipital convolutions of the hemispheres, and are known as the *direct sensory tracts*. The fibres from the tegmenta are derived from the reticular formation of the medulla oblongata, and are joined by fibres from the superior and middle peduncles of the cerebellum, and by fibres from the corpora quadrigemina, terminating apparently in the sub-thalamic region and the optic thalami. Many fibres from the external portions of the optic thalami have been traced radiating into the temporo-sphenoidal and occipital lobes. They constitute the *radiatio thalami.* Besides these there are arcuate or *association fibres,* which bring adjacent convolutions into communication.

Much patient and critical study has been given to the unravelling of the fibres of the medullary structure of the cerebro-spinal system by anatomists. Briefly stated, the conclusions drawn from their observations establish that there are three sets of nerve-centres, and three sets of nerve-fibres through which impressions are transmitted to and from the periphery and to and from the gray cortical surface of the hemispheres. The nerve-centres are the gray matter of the cord and medulla oblongata, the optic thalami and corpora striata, and the cortical surface of the convolutions. The nerve-fibres are those which connect the periphery with the gray matter of the cord and medulla, those which connect the gray matter of the cord and medulla with the basal ganglionic centres, the optic thalami, and the corpora striata, and those which bring these centres into relation with the cortical surface of the convolutions. The precise function of the basal ganglionic centres is unknown, but from their relations as above described it may be inferred that the *corpora striata* are connected with *motion,* and that the *optic thalami* are connected with *sensation.* In both there is *crossed action;* and the above inference is further emphasized by clinical and pathological data, as well as by physiological experiments.

Apoplexy attended by hemorrhage of one of the lenticulo-striate arteries into the substance of either of the corpora striata is followed by paralysis of motion of the opposite side of the body, without loss of sensation; and similar involvement of either of the optic thalami is followed by loss of sensation in the opposite side, without diminution of power of motion.

The approximate topographical relation of the anterior limit of the corpora striata to the external surface of the head may be indicated by drawing a line on each side from the stephanion to the pterion (Plate 2, Fig. 1). The same relative bearing which the optic thalami, within the head, probably hold may be mapped out by an anterior vertical line drawn from the bregma to the external auditory opening on each side, and a posterior vertical line drawn from the parietal eminence to the asterion (Plate 2, Fig. 1). A line drawn from the ophryon backward on the side of the head to the occiput, through the asterion, will indicate the position of the lateral ventricle, its anterior limitation corresponding to a line from the stephanion to the pterion, and its posterior limitation to a line from the parietal eminence to the asterion, as above described.

The operation of trephining for tapping the ventricles for intra-cranial hemorrhage is very hazardous, and requires careful consideration of the position of the corpus striatum and optic thalamus and their relations to the highly vascular region of the Sylvian fossa and island of Reil, where the cortical vessels are large and near their origin from the middle cerebral and internal carotid arteries. If the procedure is attempted, in order to avoid this important area the best position for the application of the trephine will be on a line drawn from the ophryon to the lambda, and midway between the external auditory opening and the asterion. This will expose the temporo-sphenoidal lobe about the junction of the middle and inferior temporo-sphenoidal convolutions. A fine trocar passed in a direction forward and obliquely downward will (in the adult) reach the corresponding lateral ventricle. If the ventricle be distended with blood its walls will be reached two and half centimetres, or about an inch, from the surface. In two instances within the author's experience where exploratory tapping was practised, although no benefit was derived from the operation, no ill effects were noticed, and the autopsies revealed no injury to the medullary substance even upon microscopic examination.

THE REGION OF THE EAR.

The ear (auris), or **organ of hearing**, consists of *two accessory portions*, the *pinna*, or *auricle*, for the purpose of collecting and converging the aërial vibrations to the *external meatus*, which conducts them to the *middle ear*, or *tympanum*, and the *essential portion*, the *internal ear*, or *labyrinth*, where the sensation of sound is produced by their ultimate impression upon the auditory nerve.

The pinna, or **auricle** (Plate 17), projects from the side of the head, being movably attached to the external auditory opening of the